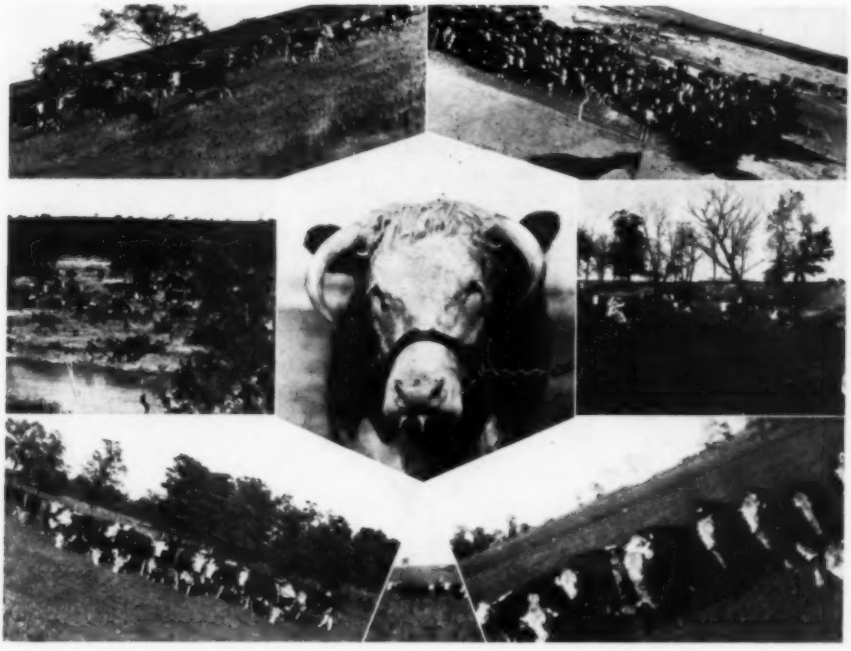
PEARL

The Journal of HEREDITY



"GREAT-GRANDCHILDREN" OF BEAU BRUMMEL
(SEE PAGE 283)

Recessive Hairlessness in the Goat

Cytology for Plant Breeders

Eugenics in Other Lands

Chromosomes of Sweet Potatoes

Four Generations of Extra Fingers

VOLUME 28 AUGUST, 1937 NUMBER 8

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their applicaiton to the improvement of plants, animals, and human racial stocks

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Photographs of Beau Brummel's "Great-grandchildren" Courtesy of U. S. Dept. of Agriculture

The

Journal of Heredity

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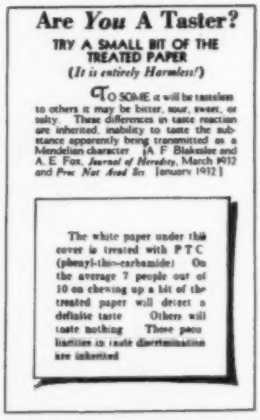
Are You A Taster?
TRY A SMALL BIT OF THE TREATED PAPER
(It is entirely Harmless!)
TO SOME a will be tasteless to others it may be bitter, sour, sweet, or salty. These differences in taste reaction are inherited, inability to taste the substance apparently being transmitted as a Mendelian character (A. F. Blakeslee and A. E. Fox, Journal of Heredity, March 1932 and Proc. Nat. Acad. Sci. January 1932)
The white paper under this cover is treated with P T C (phenyl-thio-carbamide) On the average 7 people out of 10 on chewing up a bit of the treated paper will detect a definite taste Others will taste nothing These peculiarities in taste discrimination are inherited

LEAFLETS TO DEMONSTRATE HEREDITY

Last year the "Taster test" served as an introduction to human genetic differences in many classrooms. The test is so easily made with the treated paper, and arouses such great interest that it appears to have a definite place in group demonstrations of such differences. These leaflets, size 3⅜" by 5½", are available in quantities for those who wish to use them for classroom or lecture purposes. On the back is printed an outline 4-generation pedigree chart. Sample on request. Prices: 10 for 25c; 50 for $1.00.

American Genetic Association

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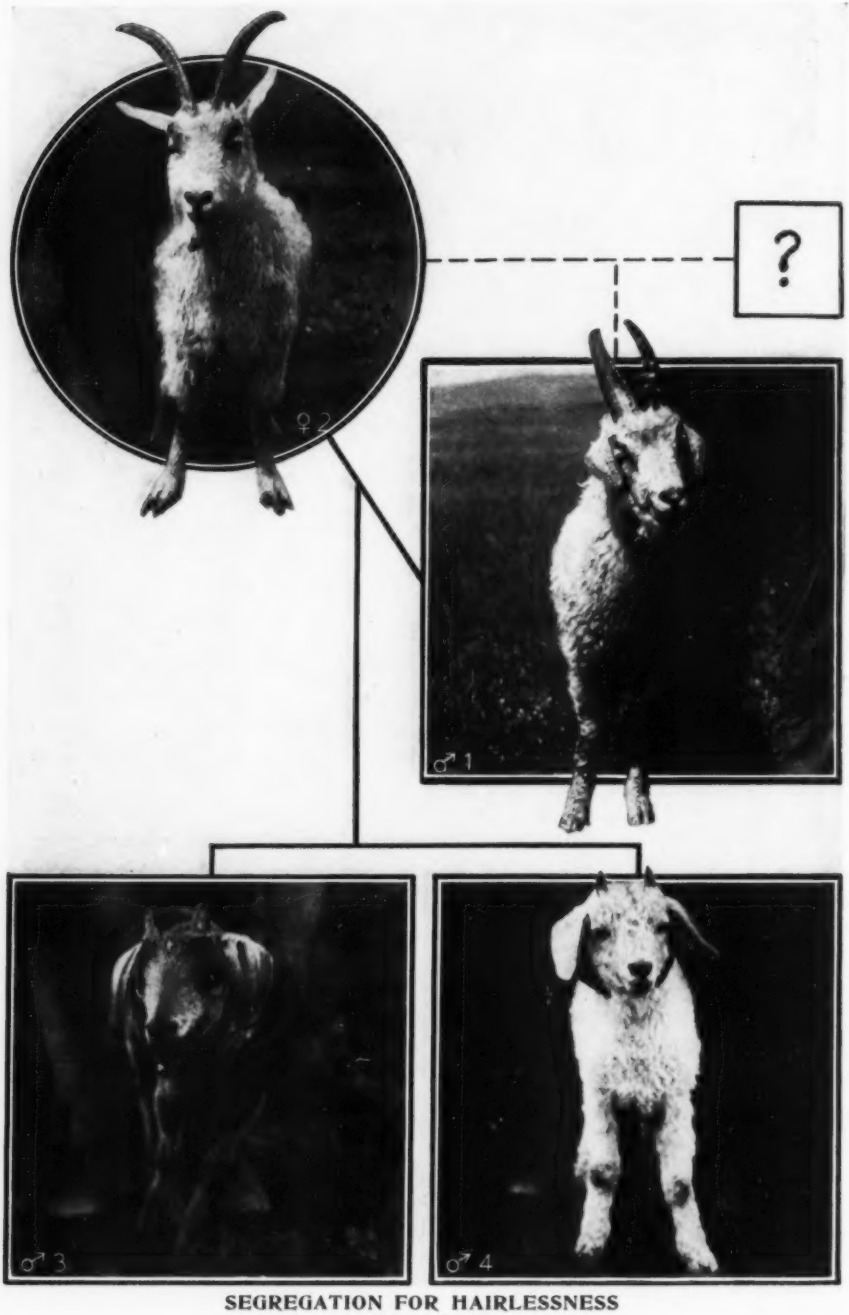

SEGREGATION FOR HAIRLESSNESS

Frontispiece

The "propositus" of this pedigree is ♂1, who was hairless as a kid, but grew a normal fleece later. His mother was normal, and his father unknown. Mated to his mother he sired one normal and one hairless kid. Simple recessive inheritance of hairlessness is suggested.

INHERITED HAIRLESSNESS IN THE GOAT

With Some Observations on Parallel Mutation

D. KISLOVSKY

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HAIRLESSNESS in the goat has been repeatedly described[8], but no notice has been made of its inheritance. Some time ago M. Trifonov described a case of hairlessness in the goat which apparently was hereditary. The he-goat, ♂ 1 (see Frontispiece), bred from the she-goat ♀ 2 and an unknown sire, was quite hairless at birth. Especial care was taken to bring him to full development. As seen in the figures he gradually developed an apparently normal fleece, though at birth he is said to have been as naked as his son, ♂ 3, described below (see Frontispiece). In order to ascertain the genetic nature of this hair-defect, ♂ 1 was bred to his dam. Two kids resulted. One was quite normal (♂ 4) and the other (♂ 3) almost entirely hairless. The two kids were about the same weight at birth. Later on the naked one ceased to develop properly, fell off in weight, and died at the age of about two months, notwithstanding that special care had been taken to keep him alive. No marked hair development was observed up to the time of his death. It is a pity that no material was preserved for histological examination.

These observations point to the conclusion that this case of hairlessness in the goat is hereditary in nature, the inheritance being most probably recessive. It is of interest that the presumably recessive form (♂ 1) developed a nearly normal fleece as it grew older. When paired to his presumably heterozygous dam a fairly good 1:1 ratio was obtained. However, only further breeding experiments with the animals of the family can definitely prove the recessive nature of this hereditary hair defect or, perhaps, demonstrate a more complicated pattern of inheritance.

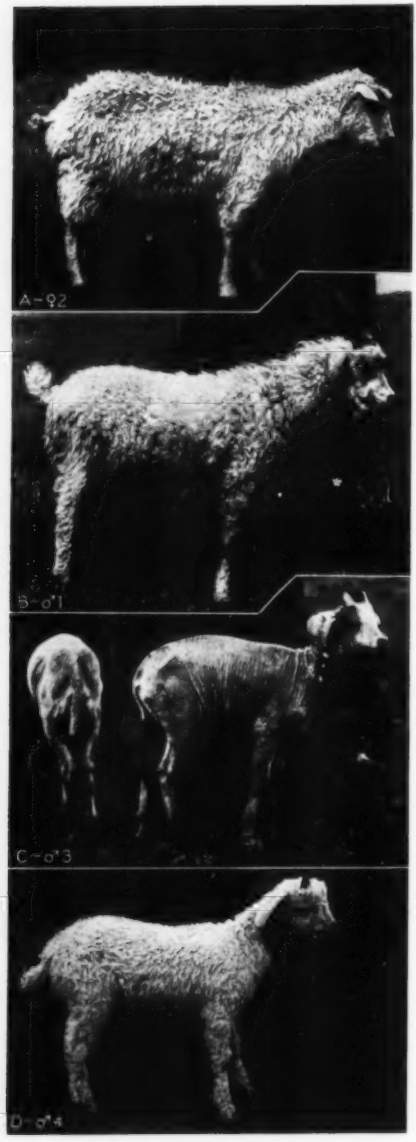
Evolution of Hairlessness

It is of some interest to note that so far hairlessness has been described as a definitely hereditary defect in forms belonging to rather widely different genera: (1) in rodentia — rabbit[4, 10], mouse[3, 7, 11, 8], rat[9, 16, 20], peromyscus[18]; (2) in artiodactyl ungulates — pig[17], cow[5, 6, 13, 15, 21], sheep[14], goat; (3) in perissodactyl ungulates — horse[2]; (4) in carnivora — dog[1], cat[12].

Other species have more or less completely lost their hair covering during the course of evolution. These belong partly to the same systematic orders as the above mentioned (as carnivora—walrus, artiodactyl ungulates — hippopotamus, perissodactyl ungulates—rhinoceros), partly to different orders (as proboscidae — elephant, cetaceans — whales, sireniae, anthropoidae—man).

In the latter cases we have evolutionary changes connected with specific ecological environment, as life in water (whales, sireniae, walrus, where the more or less complete loss of hair is mostly accompanied by a great development of a fat layer), or as life under hot climatic conditions with a rather well developed taste for bathing—hippopotamus, elephant and rhinoceros. A more or less developed reduction of the hair cover on certain regions of the body is met with in several families of apes. Man represents the ultimate degree of depilation. In some pathological cases depilation normal in man may be pushed to nearly complete absence of hair.

In the former cases of occasional hair defects the morphological parallelism is often rather striking, the more so as in such cases we may even have a similar genetic behavior. There is great temptation to see here a "homologous series"



SIDE VIEWS

Figure 1

Profile views of the hairless family of goats shown in Frontispiece. At birth ♂ 1 was as hairless as his son, ♂ 3.

as the term is used by Vavilov[19]. Thus, for instance, inheritance of hairlessness in the mouse, the rat, and the rabbit, and in the cow, the sheep, and the goat, form two such homologous series. There must certainly be in each case sufficient proof that there is not only a superficial similarity of the end stages, but that also the morphogenetic processes and the special actions of the genes involved are the same. There are already known cases where in a single species there are rather clear-cut and very similar hair defects conditioned by quite different genes (dominant[11] and recessive[3, 8] hairlessness in the mouse).

Summary

The cases of morphological parallelism in the animal kingdom may be classified in two headings:

(1) *Ecological parallelism* which may be met with in widely different species. The character appears in such cases as quite normal for certain species living under definite ecological conditions. The character seems to have developed gradually in the course of evolution. There hardly may be presumed to be identical changes of definite genes in these cases, though broadly speaking there is certainly a definite hereditary background giving the possibility of more or less analogous development in all these cases.

(2) Rather simple genetically conditioned analogous morphological cases arising suddenly, and chiefly affecting the viability of the organism (often lethals and semi-lethals). We must remember that such deviations in a certain morphological character may be conditioned by changes in quite different genes even though the same morphogenetic process may be affected. Thus we have, for instance, several types of white rabbit conditioned by distinct mutations occurring in genes located in different chromosomes, yet all interfering with pigment formation. We have two different gene mutations producing hairlessness in the mouse—one dominant and the other recessive. We must therefore be extremely cautious in assuming that a special case of morphological similarity

may be interpreted as a case falling under Vavilov's[19] law of homologous series.

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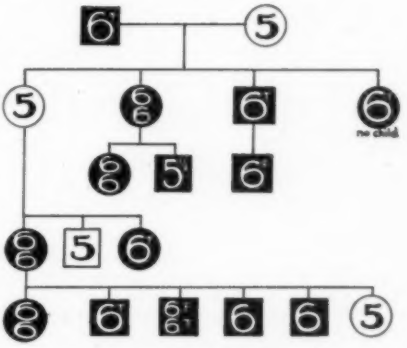
✦

FOUR GENERATIONS OF POLYDACTYLY

AN account in the newspapers of a family of six-toed dogs at Red Lake, Ontario, Canada, brought to light an interesting record of a polydactylous family in North Dakota. This has been carefully investigated, and as four generations are living, it was easy to get a complete history.

Proband, II-2, Fig. 2, has six fingers and toes, like the giant, she says, mentioned in Samuel II, 21-20, "a man of great stature with six fingers and six toes, twenty-four in all." Her father, L. D., had six toes. Her daughter had six fingers and six toes, and her son, now eighteen, has had a vestigial sixth finger removed by tieing a silken thread around it when he was born. Her sister's first-born had six fingers and six toes, and her third child six toes on the right foot. Of this sister's grandchildren, five were polydactylous, one normal—the first-born with six toes and six fingers like her mother; the second, six toes on the right foot; the third, six toes on the right foot; the



A SIX-DIGITED FAMILY

Figure 2

Extra fingers and toes inherited for four generations as an irregular dominant character.

fourth, six toes and six fingers on the left side; the fifth, six toes. Proband's brother had six toes and a son with six fingers; Proband's sister with six toes has no children.

Family tradition traces the polydactylous tendency five generations back of the proband (II-2, Figure 2), to a woman who married into the *D* family. She had the extra fingers and toes and resembled the biblical polydactyl in being something of a giant,—". . . a very strong person. She helped her husband in a blacksmith shop, and could pick up a barrel of cider and load it on a wagon. She and her husband were cousins." The inheritance of the character in the intervening generations is not definitely known.

In the pedigree shown herewith 6-6 means six fingers and six toes. In most cases the extra digit was early removed by surgical operation, thus obscuring the heredity.

Six toes and six fingers, or twenty-four digits, have occurred four times and the general distribution clearly indicates that it is an irregular dominant as in other noted cases.

V. W. Jackson.
University of Manitoba, Winnipeg, Canada.

✦

A GHOST-CHASER IN THE SUBCONSCIOUS

THE medical director of a large hospital for the mentally diseased takes the Four Horsemen of the Freudian Demonology (Incest, Homosexuality, Narcissism, and Resistance) for a witty and at times harrowing "ride."* In the course of this he makes short shrift of what he conceives to be the naively animistic human motivations postulated by the Freudian school. Dr. Harrington pictures the mind as a dynamic system, whose maladjustment must be explained on mechanistic and anatomic bases: "Looked at from our mechanistic point of view, the attempt to explain human impulses to action without taking into consideration the physiological processes which give rise to them, is like an attempt to explain what makes an automobile go without taking into consideration the fact that it has an engine or burns gasoline."

Admittedly this is not a cure-all for mental ills, but by comparison with the rather surprising anti-genetic pronouncements which the ultra-Freudians sometimes give pen to, it does seem to have something to commend it.

Dr. Harrington believes that the preservation of mental health depends primarily on four factors: "It is a matter (1) of breeding a race of potentially healthy and efficient people, (2) of giving these people the kind of education or training which will make the most of their potentialities, (3) of preserving their bodily health, and (4) of giving them the kind of environment which is best suited to their requirements." With such a broad basic outline the eugenist would seem to be in full accord.—R. C.

✦

You Tell 'Em, Doc!

Genetic Enlightenment from the *Medical Record* for June 16, 1937:

"It is also evident that at some point in the ancestral line there is a point of determination, a time when the genes which are to govern the growth of the new individual are segregated, separated and set aside from the other germ cell tissues to establish a new being. Development of the gonads has begun in the individual at birth and the tissue which make those gonadal cells are determined already in the generation back of that, the grandparent. The only evidence which tends to show the point in the ancestral line where this determination occurs is purely circumstantial and rests on the fact that while it is said that there are twenty-four pairs of genes in the human fertilized ovum, there are forty-eight ancestors in the fourth and fifth generations. This allows the inference that is between the fourth and third generation back of the individual, in the greatgrandparents that determination of the genes for a new being occurs. Addition of genes from the fourteen immediate ancestors would then tend to distort the mathematical picture of the gene ratio.

*Harrington, Milton. Wish-Hunting in the Unconscious. An Analysis of Psychoanalysis. Pp. 189. Price, $2.50. New York: The Macmillan Co. 1934.

EUGENICS IN OTHER LANDS

A Survey of Recent Developments

HILDA VON HELLMER WULLEN
Huntington, Long Island, N. Y.

THAT there is a growing recognition of the importance of eugenic principles in molding human society is shown by the formation of eugenic organizations in many countries. There has also been a gratifying trend to enact laws to prevent the propagation of defectives, and to discourage or prevent the reproduction of those known to be markedly below the average physically or mentally. Positive eugenic measures, which involve a balancing of the almost suicidally dysgenic differential birth rate characteristic of many industrial countries by an increase in the birth rate of the normal and gifted, has had to depend on less tangible agencies such as education and a voluntary realignment of social customs and economic methods. Progress in this field is therefore less easily measured, and probably has been less marked.

For the last five or six years Germany has undoubtedly stood first among the nations as the largest laboratory of eugenic experimentation in existence. Without attempting to pass judgment on the multitude of controversial questions involved in the "race purification program" of Hitler's government, the fact cannot be ignored that in Germany at the present time a concerted effort is being made on a broad front to apply the Galtonian technique of altering the inborn quality of a people through agencies under social control. While other European countries are still in the "infant stage" of mildly and rather ineffectually groping toward an adjustment of eugenical problems, Germany has been actively developing a program which will unquestionably add much to our knowledge of what can be done in a practical way to alter birth rates upward or downward at will. Even though some of the methods used in Germany may be of a nature that would not be tolerated in other countries, we must not forget that we are witnessing the development there of the first large scale experiment in human selection. For these reasons Germany unquestionably comes first in any survey of world progress in eugenic theory and practice.

The racial policy of Germany has for its purpose not only the elimination of undesirable stock, but at the same time it endeavors to encourage reproduction of the culturally superior. In order to carry out this plan in a systematic way, records and pedigrees of the entire German nation are being taken. Among the data regarding the propositus, his parents, grandparents and near kin, are physical and mental qualities and racial descent. This giant undertaking is the first step in the still greater task of "purifying the nation." It will also serve as a most important aid in the effort to prevent racial decadence. Moreover it will almost inevitably throw much light on the basic problems of just what sort of environment and what type of matings produce the most favorable conditions for the production of superior offspring.

One of the fundamental aims of Germany's policy is to make rural life more permanent, and thus prevent the steady flow to urban centers which, in the course of time, tends to produce racial suicide. In order to encourage the reproduction of the healthiest elements, a stipend is offered to parents for each additional child raised, also facilities in obtaining work for the heads of large families, and educational advantages for the children. Parents with six children, for instance, may claim exemption from income tax up to 30,000 marks a year. Childless couples, however, have to pay a tax beginning at 15 per cent.

A sterilization law has been put into practice, and is applied to the insane,

feebleminded, epileptics, criminals, syphilitics, sex perverts, and those afflicted with incurable hereditary ailments. For the purpose of determining the advisability of sterilization, special courts have been established. In the first year after the promulgation of this law, that is from January 1 to December 31, 1934, 56,244 persons were sterilized. There are, it is stated, more than 180,000 people in the German nation who should be sterilized within the near future.

The fact which places Germany ahead of other nations in regard to eugenics is, that laws are not merely passed, but have been actually and vigorously acted upon, and the results are encouraging. Germany's sterilization law is compulsory, both in the case of private individuals and inmates of institutions. There is much to be said for the German view that a law of this kind can be of little real value to humanity unless it is made compulsory.

Special effort is made to educate the young people in a way which will fit them for a useful life of cooperation, in which they will become conscious of racial responsibility. A campaign of "basic extension courses" in biological education and enlightenment regarding the responsibility of competent people to produce at least a replacement quota of children, is being carried on intensively in the schools of the Reich. This is based on a great variety of booklets and leaflets prepared especially for this purpose, and has been declared by American observers to be excellent. It has no parallel in any other nation.

Beside these aspects there are several other stipulations. For instance, persons applying for government jobs must have the proper qualifications; they must be free from all hereditary taint (erbliche Belastung). A marriage law (Gesetz zum Schutze der Erbgesundheit des deutschen Volkes) was enacted on October 19, 1935. Parties suffering from mental, hereditary or infectious disease are forbidden to marry. A certificate must be procured before marriage, in which is stated by the authorities that marriage is permitted, and any marriage contracted under violation of this law is considered void. This certificate is issued by the local Health Office or "Gesundheitsamt" which is also connected with the pre-marital advice center (Eheberatungsstelle), where healthy unions are encouraged and undesirable ones cautioned against.

Remarkable as it may seem in this age of selfishness and struggle, the German people have accepted wholeheartedly, the racial betterment plan devised by their Fuehrer, and are cheerfully and willingly submitting, regardless of sacrifices involved, to the fulfilment of the duties asked of them.

Thus the German nation has recognized, before it is too late, (and before any other nation has taken any significant step in that direction), the biological importance of improving its racial stock by bringing into action all possible means at its disposal which may contribute to this important purpose.

Eugenics in England

Eugenic reform in England represents the "persuasive approach," in contrast to the "compulsive methods" practiced in Germany. One of the most ambitious attempts to introduce a broader plan of eugenics involved the hearings and the report of a committee appointed by Sir Laurence G. Brock, Chairman of the Board of Control, on June 19, 1932, to examine and report on the information already available regarding the hereditary transmission and other causes of mental disorder and deficiency; to consider the value of sterilization as a preventive measure, etc.

The Committee held 36 meetings and studied a great deal of statistical data gathered in England and other countries, and furnished by prominent geneticists, biologists and psychiatrists.

The report of the Brock Committee on sterilization was published on January 8, 1934, and favored the legalization of sterilization in cases of: (1) mentally defective persons, or such as have suffered from mental disorder; (2) persons suffering from, or who are supposed to be carriers of, serious physical

disabilities which are transmittable; and (3) persons who are likely to transmit mental defect.

It is proposed that sterilization be carried out only with the written authorization of he Minister of Health. Furthermore, in order to safeguard the patient, the following suggestions were made:

Authorization for sterilization should be recommended by two medical practitioners; the Minister of Health should have the power to order special amendments, and to appoint an advisory committee in doubtful cases; the patient should sign a declaration of consent to be sterilized, if he is mentally capable of doing this, or a parent or guardian must do it for him. In case of mental disorder sterilization must be recommended by a psychiatrist, and the Minister of Health should consult the Board of Control.

These proposals set forth by the Brock Committee are much more complete and encouraging than any efforts attempted by the Sterilization Committee of the British Eugenics Society.

Based upon these proposals the Voluntary Sterilization Bill was submitted to the Minister by a delegation composed of representatives of the County Councils Association, the Association of Municipal Corporations, the Mental Hospitals Association, and the Joint Committee on Voluntary Sterilization.

On April 13 of this year, in the House of Commons, Wing-Commander James pointed out the necessity of carrying out the proposals of the Departmental Committee on Sterilization. Opponents of the legalization of aforesaid Bill are influenced by religious motives, but in spite of this religious opposition public opinion is steadily becoming stronger in favor of a sterilization law. In view of the fact that there are about 300,000 defectives in England and Wales, it is to be hoped that, eventually, an agreement will be reached.

A man whose name is closely interwoven with eugenics in England is Henry Twitchin, whose interest in race-betterment began in 1900. Born in England, he lived most of his life in Australia. For several years before his death in 1930, he gave £1,000 a year toward the work of the British Eugenics Society, and left the residue of his estate, as worded in his will, "for the carrying on of the propaganda which I believe to be by far the most urgent and important work possible in human endeavor."

In Scotland, the Department for Human Genetics at the Eugenics Institute gives lectures for medical students. A study of the population of Scotland is to be made in order to determine its racial origin, and to survey the prevalence of anomalies among the people.

Other Countries

In Czechoslovakia a general meeting was called together on May 5, 1936, by the Eugenics Society, to discuss eugenical sterilization. Members of the medical and law faculties of the Universities were invited to attend. The result of the meeting was unanimous approval of sterilization. The Society will appoint a Committee to draft a law, which will be submitted to the public as well as to the government. It is generally feared that the Catholics, who adhere to the Encyclica Casti Connubi, as well as the Leftist political party, will oppose the law. Socialist leaders have manifested their interest in eugenics by the organization of two departments, one for research, the other for practical study.

The doctors of Austria realize the importance of eugenical problems, and consequently that country has a Society for Eugenics and a Society of Heredity and Endocrinology. Vienna sponsored several exhibits, like the "Gregor Mendel Memorial Exhibit" and "Family Biology." So far no success has been recorded in the development of a eugenic population policy.

In Norway, Dr. Mjöen is President of the Committee for Eugenic Population Policy. Advice and opinions are gathered for the latter by a Eugenics Commission.

Hungary has created a Eugenics Association for Child-welfare. Jugoslavia publishes a periodical called *Eugenica*

which is the first of its kind in the Balkan States.

There is a Society for Racial Hygiene in Japan, which has the following aims:

1. The improvement of human heredity.
2. The betterment of social welfare.

The two departments of the Society cover research as well as practical study. Research comprises the following subjects:

1. The study of the inherited qualities of the nation.
2. Study of the conditions required for the development of a peculiarity. (In particular: mode of living; body-culture, etc.)
3. Study of eugenical laws, their enactment, and improvement.
4. The publication of a semi-monthly periodical, devoted to eugenics.
5. The publication of an annual report (in European language), etc.

Practical studies will consist of:

1. Founding a center for eugenical marital advice.
2. Encouraging and facilitating the setting up and revision of eugenical laws.
3. Regulation of public welfare along the lines of eugenics.
4. The propagation of eugenical knowledge.

The Dutch Government is much interested in the Eugenics Federation. The latter has asked the government for the following:

1. Financial and moral support for the Institution for human genetics and racial biology.
2. Cooperation with the administration in questions of eugenical population problems.
3. Obligatory lectures on genetics in all universities and colleges.
4. Measures to insure examination before marriage, advice regarding family affairs, investigation of present wage and tax systems from the eugenical point of view, study of population problems; besides these, also proper measures to prevent the propagation of inferior elements, and voluntary sterilization.

Furthermore, a book, published in 1935 and entitled *Dutch Family Book*, is given to all couples who make their marriage known in the capital. It contains advice on all questions regarding matrimony, medical, social, hygienic, and legal. Two excellent chapters deal with the necessity of medical examination before marriage and the importance of eugenics.

Canada and Australia are showing an increasing interest in sterilization. Two provinces of Canada, viz. Alberta and British Columbia, have such laws; in the Australian States of New Zealand and Tasmania, such laws have been drafted and submitted, but a definite regulation of sterilization has not yet taken place. It may be interesting to review these laws, both the ones proposed and those already enacted.

In Canada, Alberta promulgated on March 21, 1928, a sexual sterilization act, effective at once. The committee to decide upon sterilization must consist of two medical men, one of whom must be a college Professor, and two non-physicians. In the case that an inmate from an institution is to be discharged, the committee's leading physician may require the patient to be examined. If it appears that he might safely be discharged if the danger of procreation, and with it the possibility of transmitting mental disorders, were eliminated, his sterilization may be ordered and a suitable surgeon entrusted with the task. Sterilization may be performed only with the agreement of the patient, if he is capable of making such a statement, or with the agreement of a relative or guardian. Article 7 of the law stipulates that the surgeon who is authorized to perform sterilization cannot be made liable according to civil law. Up to the year 1933, 132 persons have been sterilized in Alberta; 27 were men and 105 were women.

British Columbia passed a sterilization act on April 7, 1933, which came into effect on July 1 of the same year. A Board of Eugenics is appointed to enforce the law, and its members consist of one judge from the Court of Appeals, one psychiatrist, and one person familiar with welfare work. If the director of an institution believes that an inmate, about to be released, might procreate and thus transmit insanity or even a minor mental derangement, the director may request the Board of Eugenics to order the sterilization of that inmate. The request has to be made in writing, and must be accompanied by a detailed case and family history, and the reasons must be given for which sterilization is recom-

mended. After the patient has been carefully examined, if the Board decides that the inmate might procreate children afflicted with serious mental disease, sterilization must be ordered, and a suitable surgeon must be selected to perform the operation. No sterilization may be performed without the order of the Board of Eugenics, and may be carried out only if the patient gives a written agreement, or, if not capable of doing this, a relative or guardian does it for him. Here, too, the appointed surgeon cannot be held responsible by the civil court, unless he has committed a technical mistake in performing the operation. The members of the Eugenics Committee are not permitted to accept fees—their position being purely honorary. Only the surgeon appointed to perform the sterilization may demand a fee, and the costs are paid by the institution which releases the inmate.

In Australia, Tasmania has a mental deficiency act, and this was to be supplemented by an order that mental patients, released from an institution, may be sterilized. The patient must agree, or, as is the case in other countries, a relative or guardian may consent for him. If a consent cannot be obtained, release from the institution is not permitted. This law, however, has failed to be enacted, for the reason that knowledge concerning the inheritance of mental diseases is held to be lacking in that state, and that further study of this problem is advisable. In New Zealand a committee was appointed by the State in 1924, to study mental diseases and sex crimes, and also to suggest means and ways to fight and prevent them. After some deliberation it was recommended that persons suffering from mental diseases, epilepsy, feeblemindedness or other diseases which might be transmitted to their offspring, should be ordered sterilized by a Eugenics Board. Sterilization should then be the condition under which a patient could be released from an institution, and could be performed only with the consent of the patient or his legal representative. If, after being sterilized, the patient is found to be leading an immoral life, his reinternment in the institution may be ordered. A "Mental Deficiency Bill" was to be introduced, prohibiting marriage to mentally deficient persons, and sanctioning the sterilization of all those affected by that rule. But these suggestions created a rather heated controversy all over New Zealand, so that no further action has been taken.

Marriage Laws

While the sterilization laws, as they are in effect today, are a step toward eliminating mentally diseased offspring, they do not provide for similar treatment in the case of those afflicted with hereditary physical malformations. Sweeping changes will be necessary before we can speak of a model sterilization law. In order to carry through a successful eugenical program, it will be imperative, beside taking recourse to sterilization, to introduce certain restrictions regarding marriage laws, in order to prevent marriage between healthy individuals and those who are suffering from hereditary disease. This purpose was carried out in Germany on October 18, 1935, when a law regarding fitness for marriage was promulgated. Other countries have similar laws, and though each one may differ in structure, the purpose is the same.

One of the first countries to follow this path was the United States. Michigan created such a law in 1867, Delaware and Kentucky followed in 1893, Connecticut in 1895, New Jersey in 1904, Indiana, Minnesota and Ohio in 1905. All in all, 39 States have enacted laws forbidding the marriage between persons, one of whom is afflicted with hereditary disease. Mental disease and physical unfitness are the foremost reasons cited for marriage restriction. Other laws include congenital feeblemindedness, epilepsy, social diseases, tuberculosis, and chronic alcoholism. Since it is not customary to submit medical certificates testifying to the absence of such impediments, the practical value of these laws is very slight.

Norway promulgated a law in 1918, forbidding marriage to syphilitic persons.

Individuals suffering from other social diseases or from epilepsy are permitted to marry if their partner is acquainted with the fact, and if both have received medical advice regarding the danger of the ailment.

Esthonia has a law (May 1, 1922) according to which the following persons may not marry: mentally diseased, epileptics, and persons suffering from venereal diseases.

Lithuania forbids persons afflicted with mental and social diseases to marry. (Law of February 1, 1921.)

Portugal passed a similar law on December 25, 1910. Mental patients are barred from marriage. The same applies to divorced persons, if the reason for their divorce has been an incurable disease or one which led to sexual excess.

Sweden passed a law on June 11, 1920, forbidding marriage of mentally diseased or deficient persons, epileptics, and individuals suffering from social diseases.

Finland has a law, the structure of which dates back to a Swedish Civil Law of 1734. Amendments have, in the meantime, brought several improvements. A marriage is considered void, if one of the partners has contracted marriage under false pretenses or by trying to conceal the true facts regarding existing mental or social disease.

Iceland's marriage laws state that mentally diseased, epileptics, and persons suffering from leprosy or tuberculosis are not permitted to marry. A more recent law makes the furnishing of contraceptive information compulsory in cases where the birth of children is deemed undesirable for social or medical reasons.

Denmark promulgated a law on June 30, 1922, forbidding marriage for the mentally diseased or the feebleminded; epileptic persons or those suffering from a social disease may marry only if their partner is acquainted with this fact; both must receive medical advice regarding the danger of infection.

Bulgaria enacted a law in 1883 which stipulates that persons suffering from insanity, epilepsy, feeblemindedness, and syphilis are barred from marriage. Alcoholism is also a legal reason for divorce.

Czechoslovakia has no law prohibiting marriage to any type of deficient or defective; however a decree passed on May 22, 1919, provides for the legal dissolution of a marriage if one of the partners accuses the other of periodical or permanent mental disorder, hysteria, dipsomania, use of narcotics, or epilepsy.

Similar laws exist in Switzerland (1907) and in Turkey (1926). Both countries decree that a marriage may be terminated if one of the partners has concealed the existence of a dangerous disease which is transmissible. There is, however, no provision for marriage prevention.

Mexico boasts of an excellent law, passed August 26, 1928. It prohibits marriage in the following cases: dipsomania, morphinism, habitual use of other narcotics, mental disease, idiocy, incurable impotence, and other chronic and incurable diseases which are contagious or transmissible.

Panama enacted a marriage law on December 3, 1928. It excludes from marriage individuals who suffer from physical impotence, syphilis, gonorrhea, tuberculosis, leprosy, mental disease, epilepsy or similar afflictions.

Bolivia prohibits (1932) marriage for persons handicapped by contagious, chronic and incurable disease, insanity and habitual dipsomania.

Other countries which have provided for marriage restriction laws in case of mental disease are: Argentina and Brazil, Chile and Ecuador; (the latter two include also chronic impotence and dipsomania). Guatemala takes into consideration mental disorders and contagious venereal diseases; Nicaragua, Peru, and Salvador include insanity, mental disorders, physical impotence; Venezuela considers mental disease and feebleminded-ness.

Italy's law prohibits marriage in case of mental disease; Jugoslavia provides for cases of impotence, insanity, social diseases; Monaco and Austria include imbecility, insanity and feeblemindedness; Poland provides for cases of in-

sanity and contagious, incurable diseases. Hungary for mental disease and deaf-mutism; Greece considers mental disease, and so does Spain, but adds physical impotence. Some of these countries, like Holland and Cuba, provide for legal divorce in the event of mental disease and social diseases. A liberalized divorce law has recently been enacted in England, and goes into effect in 1938. This includes incurable insanity as a valid ground for divorce. Marriages may be annulled if at the time of marriage one partner was of unsound mind, or suffered from epilepsy.

With the increasing interest in eugenics, several of the above mentioned countries have proposed sweeping changes in their laws. Argentina, Uruguay, New Zealand, Japan, Roumania, Poland and France, for instance, intend to include other hereditary diseases and the chronic use of narcotics as well as alcoholism in the list of marriage-restricting diseases.

A most radical proposal for a successful marriage law was submitted by the Spanish eugenicist Francisco de Haro in 1932, according to which no person suffering from mental disease, epilepsy, congenital feeblemindedness, morphinism, leprosy, tuberculosis, or contagious social diseases, is permitted to marry, unless previously sterilized. Furthermore, a medical health-certificate is obligatory before any marriage license may be obtained.

Considering the ever increasing number of criminals, mentally deranged and socially inadequate, particularly in this part of the world, it is to be hoped that more drastic marriage laws will be enacted in the near future. However, it would seem that, in order to check the evil at its root, sweeping sterilization laws for all types of criminals, and individuals suffering from hereditary diseases would be of a far greater value than the former in eradicating and eliminating tainted stock. For we all know that to prohibit marriage will not prevent the criminal and the feebleminded from procreating his own kind; it will not stop the syphilitic and the alcoholic from passing on his defective germplasm to his equally defective offspring. The results are more disastrous because uncontrolled and impossible to trace. Thus a stream of undesired stock will sweep on, ever growing, slowly but surely engulfing that part of humanity which still is untainted and strong.

If segregation were a desirable and practical solution, then, to house all criminals, idiots and imbeciles now enjoying absolute freedom and unhampered activity, would mean to establish immense reservations capable of caring for them. Let us not be deluded into believing that this problem will take care of itself. It is very real and right in our midst. It is the author's conviction that sterilization alone (and in practice probably only compulsory sterilization) can bring the solution, and stop further deterioration of a human stock already dangerously tainted.

✦

SIMPLIFIED CYTOLOGY

SINCE Waldeyer named the chromosomes in 1888, these tiny inhabitants of the cell nucleus have loomed increasingly large in our genetic consciousness. The connection between the nucleus and heredity had been guessed by Haeckel even before these tiny actors in the drama of cell division had their names on the program. This classical biological prophecy has been abundantly fulfilled and exceeded as chromosomes have been analyzed into chromatids and chromomeres; and as the "ids," "pangens" and "deteminers," have given way to the more exact concept of the genes. These now have a street and number in the chromosomal suburbs almost as exactly defined as the home of the human commuter, whose fabrications on the body social are variously located in time, space and effect, but whose place of residence is determinable within the mutational limits of migratory human trends. Aerial photography gives us a picture of these "human sociological genes" neatly arranged in rows which do not differ so very much in general outline from the pictures of salivary gland chromosomes

in fruit flies and other diptera now being discussed by the cytologists with the enthusiasm of real estate agents laying out a new subdivision.

The real estate boom of the anatomy of the cell has greatly clarified our genetic concepts and made fundamental additions to some of them. It has also added much to our practical understanding of heredity as exemplified in the breeding of new varieties of domestic plants and animals. The extent to which this new knowledge has had practical fruition in the production of new varieties of plants may still seem disappointingly small in view of the enthusiasm of our chromosomal real estate agents. A few varieties of crop plants have been "made-to-order" by the application of purely genetic methods. The production of "crossed corn," already a large and rapidly growing industry, owes its origin almost exclusively to genetic concepts, and is perhaps the most imposing example of genetics applied to agriculture. A large contribution has also been made in the production of disease resistant grains, vegetables, etc., but the fact remains that much of plant breeding is at the moment still an art which made great progress before Mendelism was rediscovered, and has continued to make very significant contributions to our agriculture with an almost painfully complete ignoring of Mendelian principles. Some of this apparently incomprehensible failure of knowledge to be transmuted at once into power is due to the newness of what we have learned about heredity. The application of knowledge in the arts is always a slow process, but, as is stated in the introduction of the booklets under review,* the time has now arrived when to say that a plant breeder is succeeding without any help from genetical or cytological knowledge is like saying that the users of Braille are enjoying the masterpieces of literature without the intervention of anyone else's eyes. Obviously in a culture where everyone was blind the production of books in Braille would be an extremely difficult process.

Present-day knowledge of genetics and cell mechanics is helpful in so many ways that the plant breeder who chooses to ignore these aids to his work is like a conservatively minded carpenter who insists on using a dull hand-saw when he has on his bench a sharp and swift electric saw, one of that multitude of useful technicological by-products of Faraday's putterings with fields of force which surround magnets. (GLADSTONE: "But what *use* is it?" FARADAY: "Some day you politicians will be able to tax it" —and *do* they!) The ways in which cytogenetic knowledge helps the plant breeder are legion and depend in considerable measure on the material the breeder is working with. Two brief examples: When by doubling the chromosome number one may produce "at one jump" a fully fertile, true-breeding form from a sterile hybrid, there is obviously great potential value in such a method. This phenomenon of amphidiploidy "is now known to be fairly widespread among the flowering plants, though certainly exceptional elsewhere."† The use of haploids in the production of pure lines has recently had its first practical application in tomato breeding, as noted in the JOURNAL.‡

To make easier the way of the novitiate explorer in the Land of the Chromosomes, the Imperial Bureau of Plant Genetics has recently issued two booklets which deal with this subject. Putting the cart a little before the horse, the Bureau issued in October, 1936, a 28-page booklet dealing with "The Experimental Production of Haploids and Polyploids." This gives in brief what has been learned about methods for increasing and decreasing the number of chromosomes by complete sets, through chemical, physical, and biological means.

*Imperial Bureau of Plant Genetics, School of Agriculture, Cambridge, England. Experimental Production of Haploids and Polyploids, October, 1936. An Outline of Cytological Technique for Plant Breeders, February, 1937. Price 5/ and 1/6 respectively.

†ANDERSON, EDGAR. Supra-Specific Variation in Nature and in Classification. *American Nat.* 71:223-235. May-June, 1937.

‡A Haploid Marglobe Tomato. *Jour. of Hered.* 27:433-435. 1936.

The rather crude methods now available, such as the use of heat or cold, of infecting plants with bacteria or chemical solutions or of squirting electrons into them (X-rays), are described with detailed references to the literature. Following this is a summary which lists quite completely all the polyploids which have actually been produced by hybridization in the various economic forms throughout the world.

Three months later the Bureau followed up this contribution by making available to the plant breeder descriptions of the simplest and most effective cytological techniques for viewing the chromosomes (be they haploid, diploid, or polyploid) so that he can tell what changes the treatments described in the earlier circular might have induced. The very concentrated nature of this discussion would seem to make rather rich informational pabulum for the practical worker, unacquainted with cytological technique. Thus the handling of the microscope is disposed of in about a page and a half,—amply brief space to inculcate into the beginner enough skill to hope to see most chromosomes. Fortunately the bibliography accompanying these directions makes it possible to find more detailed sources of knowledge if these highly compressed informational riches prove inadequate. We may only hope that enough enthusiasm will be engendered so that failure does not produce an attitude of despair.

Not only are the mechanics of chromosome behavior often of vital importance to the plant breeder, but a clearer and more detailed understanding of the fundamental workings of the cell and of heredity will add enormously to the intellectual stimulus and satisfaction of those who work with plants. For that reason, as well as for their purely utilitarian value these pioneer guides to the land of the chromosomes are most encouraging. The ultimate Baedeker of the nucleus will doubtless have to be a thicker volume, and illustrated with charts, photographs, and sketches of the workings of that Omnibus of the Invisible, the microscope, and of the kind of scenery one is likely to encounter along the way.—R. C.

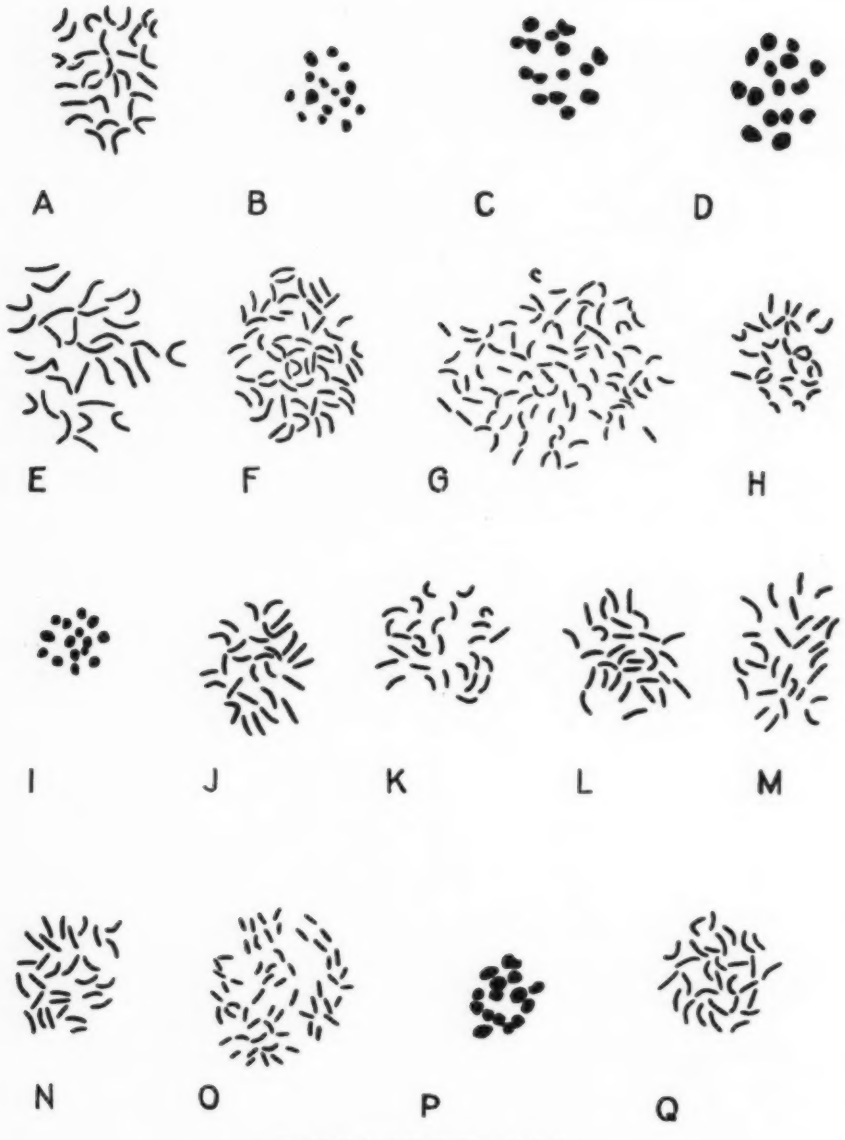
"Proved Sires" Listed by Bureau of Dairy Industry

The names of 1,553 "proved" dairy sires, together with a record of each sire's breeding performance, have just been published by the U. S. Department of Agriculture. Each sire was proved in a dairy herd-improvement association herd by comparing the production records of five or more of his daughters with the production records of their dams.

Publication of this list of proved sires is a new step in the Bureau's cooperative efforts with the State dairy extension services to raise the level of milk and butterfat production in the average dairy herd. The list includes all sires proved since November, 1935. A similar list will be issued annually hereafter which will include all sires proved within the preceding 12 months.

All association sires whose dam-and-daughter records were tabulated to show their breeding values are included in the list, whether the sire in question proved to be good, poor, or just average in his transmitting ability. The Bureau believes the information will be a valuable guide for dairymen in eliminating poor sires from further use and in selecting good ones for more extended service. The information should be of interest not only to the owners of the sires, but also to all prospective purchasers of new herd sires. Even though many of the sires were dead by the time they were proved, the information is still valuable in that it gives an indication of what may be expected from young untried sons of these sires that are available for service.

Copies of the list will be carried by all association testers for consultation by the association herd owners. Dairymen who wish to establish or maintain a complete file of the annual lists for future reference may obtain copies by purchase from the Superintendent of Documents, Government Printing Office, Washington, D. C. The list just published is Miscellaneous Publication 277. The price is 15 cents a copy.—U. S. Dept. of Agr. Off. of Information.



IPOMOEA CHROMOSOMES

Figure 3

Chromosomes in Ipomoea and related genera. *A—Ipomoea arborescens*, (2*n*=30). *B—I. purpurea* v., (*n*=15). *C—I. setosa*, (*n*=15). *D—I. digitata*, (*n*=15). *E—I. pandurata*, (2*n*=30). *F—I. ramoni*, (2*n*=60). *G—I. batatas* v., (2*n*=90). *H—I. lacunosa* v., (2*n*=30). *I—I. pandurata*, (*n*=15). *J—Quamoclit coccinea*, (2*n*=28). *K—Q. coccinea* v. hederifolia, (2*n*=28). *L—Q. pinnata*, (2*n*=30). *M—Q. coccinea* v. *hederifolia* × *coccinea* hybrid, (2*n*=28). *N—Q. pinnata* × *coccinea* hybrid, (2*n*=29). *O—Q. sloteri*, (2*n*=58). *P—Calonyction aculeatum*, (2*n*=30). *Q—Operculina tuberosa*, (2*n*=30). — Approx. 2750×.

THE CHROMOSOME NUMBER IN IPOMOEA AND RELATED GENERA

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DURING the past few years much importance has been attached to the study of the number, structure and behavior of the chromosomes in economic plants. This is especially true when a knowledge of the relationship of the cultivated plant to other members of the same genus is desired. Although the chromosome number is not the only factor, it is considered of importance in determining relationships. In *Ipomoea* the similarity of the sweet potato, *I. batatas* L., to other members of the genus suggested an interesting study, particularly with a view to interspecific hybridization. The recent work of Tioutine[16] on hybridization between some of the larger rooted forms of *Ipomoea* and the sweet potato has indicated the necessity of such information.

Most of the reports on chromosome number in the genus *Ipomoea* have originated in Japan and have dealt chiefly with the cultivated morning glories, that is, *I. purpurea* Roth, *I. hederacea* Jacq. and *I. nil* Roth. These reports and those of Heitz[4] and Wolcott[18] are listed in Table I. Other genera, such as *Quamoclit* and *Calonyction*, are included here because they have been considered by many to be members of the genus *Ipomoea*.

From this list it appears that the diploid chromosome number of most of the species of *Ipomoea* and also of some of the other related genera is 30. The sweet potato seems to be an exception and according to Kano[10] this is not a polyploid number, although he admits that the number is questionable.

Materials and Methods

The seeds of the species and varieties used in this study were secured from various seed firms and from collectors in the United States, Central and South America, and Europe. The roots of the varieties of *I. batatas* were secured from the United States Department of Agriculture through the courtesy of Dr. V. R. Boswell, while buds of other varieties were collected from Puerto Rico through the kindness of Dr. B. F. Lutman of the Vermont Agricultural Experiment Station.

The nomenclature used in this paper was derived from House's monographs.[5-7] These were very valuable because of the variety of names used for this group. The collection of specimens in the National Herbarium in Washington, D. C., was also consulted.

Root tips and flower buds were used in determining the chromosome numbers. These were fixed in a variety of fluids. Flemming's medium gave the best results with the root tips, and Nawaschin's the better fixation in flower buds, although no fixing fluid was entirely satisfactory for the latter. Both types of material were carried through the usual xylol-paraffin method and the sections cut 10-13 microns. Iron alum-haematoxylin was used as a stain. The aceto-carmine smear method was used with the same inconsistent result.

All drawings were made with the aid of a camera lucida and the use of a 15× compensating ocular with a 90× 1.3 apochromatic objective.

Results and Discussion

Ipomoea

It appears from the results (Table II and Figure 3 *A-I*) that this genius is essentially a haploid one, the only exceptions being *I. ramoni* and *I. batatas* (Figure 3 *F, G*). This is essentially in agreement with the reports in the recent papers listed in Table I, especially those of Wolcott.[18] The count by Kano[10] for *I. batatas* ($n = 42$?) might be accounted for because of the difficulty in preserving bud material. In fact, in the

somatic counts determined for this study, only the extremely favorable chromosome plates were usable with any degree of accuracy. The size and large number of the chromosomes made the determination difficult. The high chromosome number in this species is made even more interesting in that Tioutine[16] was able to secure seed from it after pollination with *I. pandurata* and other tuberous rooted forms. The chromosome number of *I. pandurata* is thirty (Figure 3 *E, I*) and it is a diploid. Since such crosses are possible it can be assumed that *I. ramoni* ($2n = 60$), a member of the same subsection as *I. batatas*, might have had such an origin.

The constancy of the counts in the varieties of *I. purpurea, I. hederacea,* and *I. batatas* is in agreement with many other reports in a variety of genera such as *Gladiolus,*[1] *Tulipa,*[19] *Phlox,*[2] *Arachis,*[8] *Cucurbita*[14] and many others.

Wolcott[18] has reported what he considers a hybrid between two species. This suggestion and Tioutine's results which were noted above make it seem that interspecific hybridization is possible. However, during the course of this study, which extended over a period of three growing seasons, a total of over 500 interspecific and intervarietal pollinations were made in this genus, but none was successful.

Quamoclit

Many of the workers (Nohara[13], Nakajima[12], Kagawa and Nakajima[19], Wolcott[18]) who have studied this genus genetically and cytologically have noticed the different chromosome numbers among apparently related species. These reports have been confirmed again (Table II, and Figure 3 *J-O*). The most interesting situations in this group are the results of hybridization between those members of the genus having different chromosome numbers. Attention has been called particularly[9,13] to the similarity between these hybrids and *Q. sloteri.* This similarity extends further than to the external characters in that the chromosome numbers are half that of *Q. sloteri,* suggesting the probable

TABLE I.—Chromosome numbers previously reported.

Name	*n*	*2n*	Reported by
Pharbitis hederacea Choisy (*Ipomoea hederacea* L.)		30	Kano[10], Wolcott[18].
			Kano[10], Wolcott[18].
P. hispida Choisy (*I. purpurea* L.)	15	30	Kano[10], Nagao[11], Yasui[20].
P. nil Choisy (*I. nil* Roth)	15		Nakajima[12].
"	12-14	24-28	Ogha[5].
" (haploid)		15	U[17].
Ipomoea edible (*I. batatas* L.)	42?		Kano[10].
I. lacunosa L.		30	Wolcott[18].
I. carolina Pursh.		30	"
I. sagittata Cav.		30	"
I. pandurata Meyer		30	"
I. setosa Ker	15	30	Nakajima[12], Wolcott[18].
I. rubrocaerula Hook.		30	" "
I. purga (Wender.) Hayne		24-28	Heitz[4].
I. biloba Forsk. (*I. pes-caprae* [L.] Roth.)	15	30	Sugiura[15]. Wolcott[18].
I. sp.		28	Nakajima[12], Kagawa and Nakajima[9], Kano[10]. Wolcott[18].
Quamoclit angulata Bojer. (*Q. coccinea* [L.] Moench)		28	Nakajima[12], Kagawa and Nakajima[9].
Q. coccinea hederifolia (L.) House	14	30	Nakajima[12], Kagawa and Nakajima[9], Kano[10].
Q. pennata Bojer. (*Q. pinnata* [Desr. Boj.])	15	58	Nakajima[12], Kagawa and Nakajima[9], Kano[10].
Q. sloteri Hort.			Kano[10].
"	30	29	Nohara[13], Kagawa and Nakajima[9].
Q. angulata (coccinea) × *Q. pennata* (pinnata)		29	Kagawa and Nakajima[9].
Q. coccinea hederifolia × *Q. pennata* (pinnata)		30	Kano[10], Nakajima[12], Wolcott[18].
Calonyction aculeatum L.			

origin of this form by amphidiploidy. Such hybrids are intermediate between the parents, completely sterile and have 29 chromosomes (Figure 3*N*). One such cross was made, *Q. pinnata* × *Q. coccinea*, and it is apparently the reciprocal of some of those made previously[9,13]. In addition to this a cross between *Q. coccinea* and *Q. coccinea* v. *hederifolia* has been made along with its reciprocal. Here, however, the parental chromosome numbers are the same and the hybrids were fertile although intermediate between the two parents in external characters.

Summary

The basic chromosome number in *Ipomoea* is 15. Most of the species and varieties which were investigated are diploids. The two exceptions are *I. ramoni* and *I. batatas*, and these are respectively a tetraploid and a hexaploid. The basic chromosome number in *Quamoclit* varies in different species, being either 14 or 15. Certain reported hybrids are discussed in relation to the chromosome numbers for the species in both groups.

TABLE II.—Chromosome Numbers Found in Ipomoea and Related Genera.

Name	*n*	2*n*
Ipomoea		
Orthoipomea		
Leptophyllae		
I. leptophylla Torr.		30
Arborescentes		
I. arborescens (Humb. & Bonpl.) G. Don		30
Pharbitis		
Cephalanthae		
I. ruber (Vahl.) Millsp.		30
Hederaceae		
I. purpurea (L.) Lam.		
var. striped violet		30
white with red throat		30
black blue		30
carmine	15	30
striped red		30
spotted violet		30
rose		30
lilac		30
light blue		30
double—semidouble	15	30
white		30
I. hederacea (L.) Jacq.		
var. imperialis	15	30
imp. Japanese purple		30
" white	15	30
" mottled	15	30
giant Japanese		30
japonica viridiflora	15	30
I. nil (L. in part) Roth		30
I. learii Paxton		30
Batatas		
Erpipomoea		
I. pes-caprae (L.) Roth		30
I. setosa Ker.	15	30
Palmatae		
I. cairica (L.) Sweet		30
I. digitata L.	15	30
Jalapae		
I. pandurata (L.) G. F. W. Mey	15	30
Aquisepalae		
I. ramoni Choisy		60
I. lacunosa		
var. white	15	30
purple	15	30
sibirica	15	30
I. batatas L.		
var. White Sport		90?
Big Stem Jersey		90?
Nancy Hall		90?
Key West		90?
Porto Rico		90?
Seedling 169-3		90?
" 259		90?
" 24171		90?
" 312		90?
Vineland Bush		90?
I. violacea L. (*I. rubro-coerulea* Hook.)		
var. Baby Blue	15	30
violacea vera		30
Quamoclit		
Q. coccinea hederifolia (L.) House	14	28
Q. coccinea (L. Moench)		28
Q. pinnata (Desr.) Job.		
var. red		30
white	15	30
pink		30
Q. Sloteri Hort.		58
Q. lobata (Llav. & Lex.) House		28
Operculina		
O. tuberosa Meissn.		30
O. dissecta House		30
Calonyction		
C. aculeatum (L.) House	15	30
Merremia		
M. distillatoria Blanco.		30
Unclassified		
Ipomoea sp. (2)	15	30
Quamoclit sp. (1)		28

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◆

Birth Rates Can Be Controlled

THE birth rate is dropping like a plummet in all classes except the unskilled, the illiterate, the non-self-supporting, where it remains very high. We are recruiting the nation from these groups, and the time has come for everyone, both Catholics and "birth controllers" to stop squabbling and get together to protect the general birth rate of those classes which the country needs.

How can matters be corrected? First we should tax the childless for the benefit of large families. Second preach against race suicide. Third and most important, give tax relief to self supporting, would-be parents by lowering the relief rolls. The enormous flow of useless and degenerate people must be lessened at its source in both city and country slums.

To fight about how this is to be done, to quibble about methods, is to draw a smoke-screen over the real issue. This is at all costs to be avoided for it is just what those who profit from cheap labor and ignorance want. No one particular method, such as sterilization of degenerates, is necessary.

If society as a whole wishes to reduce the birth rate of the unfit, means and methods can be found. Catholic Ireland is an example of how the will of the people in regard to the birth rate is what counts, for despite the fact that neither birth control nor sterilization are practiced, Catholic Ireland has for the past century often had the lowest birth rate in all Europe. All that is needed is for church and state and all social agencies to cooperate, and ways and means acceptable to the community will be found.

* * *

The *will* to grapple with our great problem of increasing dependency alone is lacking. There is no ethical quarrel about the exact means important enough to be a stumbling block. The kind of birth control to which some churches object is not indispensable.

Our first step should be to get all definitely feeble-minded females under guardianship. At present only one-tenth are so registered, and most of the rest are freely reproducing their like, for us and our children to support through taxes.—Caroline H. Robinson.

A GENETIC HISTORY OF HEREFORD CATTLE IN THE UNITED STATES*

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THE Hereford breed originated in and around Herefordshire, England, from stock a part of which may have come from Holland. Herefordshire was given credit for having better than average cattle as early as 1627.[10] The early breeders seemed to consider their systems of breeding as part of their trade secrets and very few records have been preserved. The Tomkins famliy, one of the earliest improvers of the breed, and their successor, Price, used inbreeding in their herds. Tomkins and Price together bred a closed herd for 70 years with no ill-effects.[12] Hewer, another early improver, kept 5 families or strains in his herd so that he could produce bulls for his own use and still not inbreed too much.[12] Apparently when the early breeders were unable to secure good bulls unrelated to their cows, they resorted to inbreeding. It is likely that the early Hereford breeders used the contemporarily famous Bakewell system of breeding, but records are too fragmentary to measure the amount of inbreeding that actually did take place then.

The first importation of Herefords to the United States was in 1817.[13] The first herd was established about 1840 near Albany, New York. A few small herds were established in Maine and Ohio from 1840 to 1860. Economic conditions from 1860 to 1870 were not conducive to an expansion in the cattle business and there were very few Hereford herds in the United States in 1870. Herefords were imported in large numbers during the range cattle expansion in the western part of the United States that began late in the seventies. From 1848 to 1886 3,703 Herefords were imported. It is estimated that only 200 of these animals were imported before 1880.[13] In 1886 the American Hereford Breeders Association passed a regulation which required a $100.00 registry fee on all imported animals; this stopped importations until the fee was revoked in 1893. From 1893 to 1918, 1,109 animals were imported, but no animals have been imported since 1918.

The British herdbook was established in 1846 by Eyton, and taken over by the breed association in 1878. The American Hereford Record was started in 1879. The American Hereford Breeder's Association was established in 1881 and it purchased the first two volumes of the American Hereford Record in 1883. The American Hereford Breeder's Association had 145 members in 1882 and 14,946 in 1932.[1] The association recorded between two and five thousand animals per year in the years around 1890. The annual number of entries at decennial years were as follows: in 1900 about 10,000; in 1910 about 24,000; in 1920 about 102,000; in 1930 about 101,000.[1]

Among the important early herds of Herefords in the United States there was one, established in 1877 and bred until 1916, which had a more profound influence than the others on the breed, especially during the last decade of the present study. This was the Gudgell and Simpson herd founded by Charles and James Gudgell at Independence, Missouri. T. A. Simpson joined the firm in 1880. This breeding firm was interested in selling cattle to the ranchmen of the western part of the United States. They imported and bred many noted individuals, one of the most important being Anxiety 4th 9904. This

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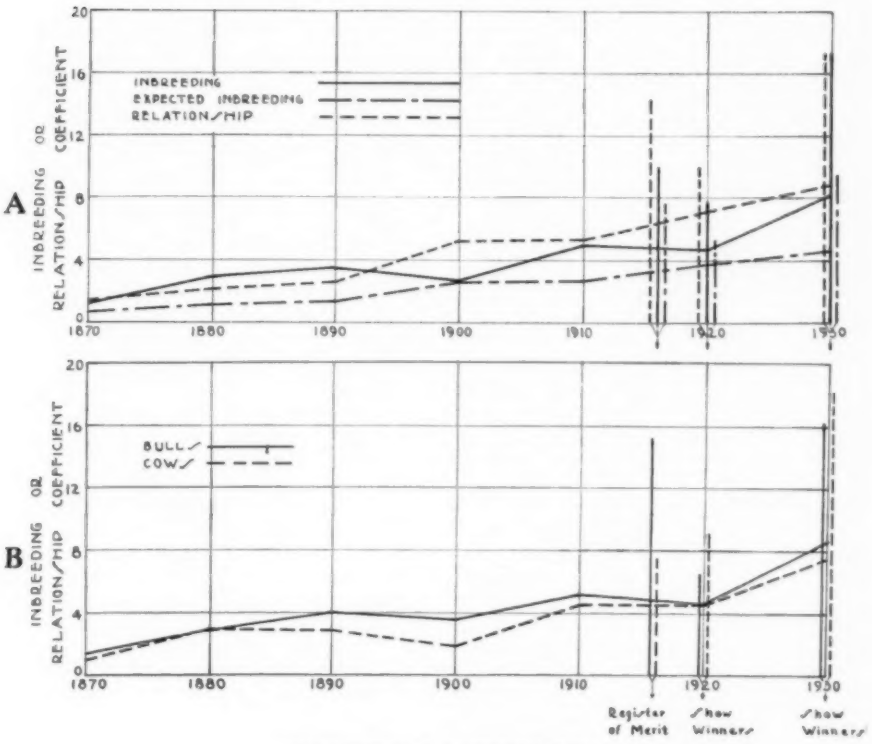
bull was imported in 1881 and was used extensively in the herd. Like many other breeders of that time, Gudgell and Simpson tried to improve their herd by outcrossing. They were unsuccessful with that system and started on a system of linebreeding to Anxiety 4th. They started too late to do much inbreeding while Anxiety 4th was himself still alive, but they made extensive use of his son, Don Carlos 33734, and his two grandsons, Beau Brummel 51817 and Lamplighter 51834; they used a number of other sons and grandsons, though less extensively. From around 1890 to the time of the dispersion of their herd in 1916, they followed a program of breeding from within the group of sons and daughters and grandsons and granddaughters of Anxiety 4th. They furnished the foundation stock for many modern breeders who started in the business around 1900. A number of breeders have maintained the concentration of Anxiety 4th's blood following the dispersal of the Gudgell and Simpson herd. The term "straight-bred" was coined to describe any animal which descended entirely from animals in the Gudgell and Simpson herd about 1890. The inheritance of such animals comes almost entirely from sons and daughters of Anxiety 4th and from daughters of North Pole. Since about 1920 there has been keen argument among Hereford breeders about the wisdom of the "straight-bred policy. This situation is reminiscent of that among the Shorthorns nearly two decades earlier when the advocates of "straight-Scotch" and of "Scotch-topped" pedigrees were each kept very busy explaining why the other was wrong.

The aims of this study were: first, to find what part inbreeding has played in the development of the Hereford breed in the United States since 1860; second, to see whether the breed has developed as a single homogeneous group of related animals or whether it has been broken up definitely into families; third, to find how much influence certain individual animals have had on the breed; fourth, to find whether a different practice has been followed in the development of the Herefords which win high prizes at the shows than was followed in producing the average animals of the breed; fifth, to learn how much influence individual foundation animals have had on the breed at the present time and whether the foundation animals were bred by only a few or by many breeders.

The methods used in this study were developed by Wright[15] and Wright and McPhee.[17] The following breeds have been analyzed by these methods: British Shorthorn cattle,[11] Clydesdale horses in Scotland,[4] Jersey cattle in England,[14] Ayrshire cattle in Scotland,[6] Rambouillet sheep in the United States,[5] Holstein-Friesian cattle in the United States,[7] Brown Swiss cattle in the United States,[18] and Poland China hogs in the United States.[9] The following subdivisions of breeds have been studied by these methods: the Duchess family of Shorthorns as bred by Thomas Bates,[16] the British Dairy Shorthorns,[11] the Shorthorn prize winners in the United States.[3]

In the present study samples were taken at ten year intervals starting with 1870 and extending to 1930. Each sample except the one in 1870 consisted of 250 bulls and 250 cows chosen from the recorded calves born in the year in question. The animals in the samples were chosen by taking the first animal of the correct sex and age on certain pages of the herd book. The animal's name, breeder, or owner was not considered. In the 1870 sample all of the animals recorded as born in 1870 were taken from the first seven volumes of the American Hereford Record. There were only 65 bulls altogether in this group. Sixty-five cows born in the same year were selected at random. There were 111 animals in the Register of Merit[1] up to and including the 1934 shows, and these animals were used as one sample. A sample of show animals comparable in birth date to the 1920 random sample of the breed was selected. The first, second, and third prize individuals at the International Livestock Exposition at Chicago and the American Royal Livestock Show at Kansas City, and the first prize individuals at the Southwestern Exposition and Fat Stock



INBREEDING COEFFICIENTS

Figure 4

A—Coefficients of inbreeding and *inter se* relationship from 1870 to 1930, for samples of the whole breed, and for certain special samples, and *B*, the coefficients of inbreeding for bulls and cows for the same period.

Show at Fort Worth and at the National Western Stock Show at Denver, were selected for this sample. In addition the champions of all the shows listed in the annual review published by the *American Hereford Journal* were included. The above shows for 1920, 1921, and 1922 were used for the 1920 show sample. Duplications were avoided. The 1930 show sample was selected in the same manner from the above shows of 1930, 1931, and 1932 except that the Great Western Livestock Show at Los Angeles was substituted for the International Livestock Exposition in 1930 and 1931. There were 104 bulls and 107 cows in the 1920 show sample and 100 bulls and 107 cows in the 1930 sample.

The base date to which pedigrees were to be traced was set at 1860 because this seemed about as far as all pedigrees could be traced completely on both sides. This would make all figures for inbreeding in this study relative to the foundation stock of 1860 but in many lines there did not happen to be an ancestor born in that year. In practice all lines were traced far enough to be sure that the next ancestor could not have been born later than 1860. This made the true base date a little earlier than that. It was beween 1857 and 1858 for the 1930 sample. Traced back to 1860, nearly all lines were among English herds.

Two-line pedigrees were used in all the larger samples. Complete pedigrees

were used in the 1870 sample and four-line pedigrees were used in the Register of Merit sample. Hollerith cards were used for sorting and tabulating according to the method outlined by Brandt and McCrabb.[2]

Inbreeding

The average coefficients of inbreeding and *inter se* relationship found in the Hereford breed at the various periods are shown in Table I and Figure 4*A*. The coefficients of inbreeding in the table represent the percentage of those genes for which the breed was heterozygous in 1860 for which the breed would be expected to become homozygous since then because of the inbreeding practiced.

The coefficient of inbreeding increased gradually from 1860 to 1930 with the exception of slight decreases in 1900 and 1920. These slight decreases may have been only sampling errors but the lower inbreeding occurred just after prices had begun to rise and an era of profitable expansion was under way. It seems reasonable to suppose that such an increase in exchange of breeding stock would have led to the intercrossing of families which had been beginning to separate from each other during the previous period of more stagnant trade. Moreover there was a large increase in the popularity of the Gudgell and Simpson cattle from 1910 to 1920 and there must have been in 1920 a very large number of herds which were practically in the stage of making their first or second topcross with Gudgell and Simpson cattle on foundation stock which came from other families. Hence the lower inbreeding in 1900 and in 1920, although not statistically significant, seems logical in view of the general breed history.

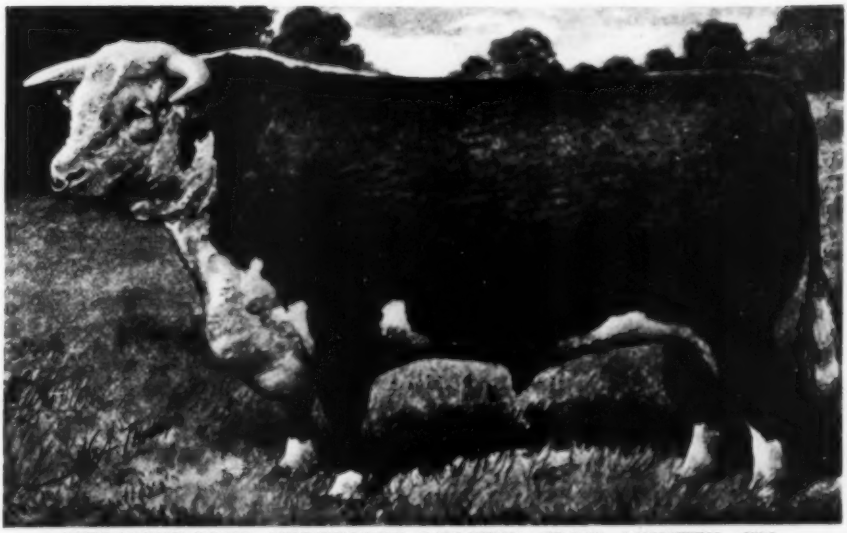
The rise in the percentage of inbreeding from 1920 to 1930 was faster than during the other periods. This was no doubt the result of the increased popularity of the "straight-bred" breeding during the period. The special samples show a higher coefficient of inbreeding than do the corresponding random samples. The inbreeding of the Register of Merit sample was larger than that of the 1920 sample by 5.4 per cent. This difference is about 4½ times its standard error. Similarly the 1920 show sample exceeds the 1920 sample by 3.2 per cent, a difference which is about twice its standard error. The inbreeding of the 1930 show sample exceeds that of the 1930 sample by 9.2 per cent, a difference about 4½ times its standard error.

The percentage of inbreeding for the bulls and the cows is shown separately in Figure 4*B*. In all of the regular samples except 1880 the bulls had a slightly higher percentage of inbreeding than the cows but the differences were not significant. The bulls in the Register of Merit were more inbred than the cows by a difference of 7.6 per cent which was about 3½ times its standard error. Perhaps this is an argument for the use of inbred sires, since this group is supposed to represent the very best breeding animals of the breed in recent years.

The inbreeding coefficient of 8 per cent found in the Hereford breed in 1930 is somewhat higher than that found in the Holstein-Friesian, Ayrshire, Jersey or Brown Swiss breeds, but the base date was earlier for the Herefords. If the base date for the Herefords or Shorthorns had been chosen to correspond to the base dates used in the other cattle studies, the amount of inbreeding found might have been very nearly the same.

The 8 per cent inbreeding for the breed in 1930 represents a decrease in heterozygosis of only 0.68% per generation* during the period from 1860 to 1930. This decrease is slow as compared with the decrease in heterozygosis in the 1930 show sample which is about twice as fast. The higher percentage of inbreeding in the 1930 show sample is partly a result of the "straight-bred" breeding. The extreme mildness of the 0.68% inbreeding per generation actually practiced may be made more vivid by contrasting it with the 19% loss of

*This figure was calculated by dividing the coefficient of inbreeding by the number of generations less one. The one generation was deducted since it is impossible among bi-sexual animals for any inbreeding to be visible in pedigrees traced only one generation.



"STRAIGHT-BRED HEREFORDS DESCEND FROM ANXIETY 4TH

Figure 5

Anxiety 4th 9904, bred by Carwardine and used by Gudgell and Simpson, was one of the most important sires in the Hereford breed. He was largely responsible for the Anxiety line of breeding which is still popular among Hereford breeders in the United States. He is the one animal most often mentioned in connection with the so-called "straight-bred Herefords." He had a relationship of 18.5% to the breed in 1930.

heterozygosis per generation to be expected under brother-sister mating or the 11% per generation to be expected in a herd entirely closed to outside blood and consisting of one male and many females in each generation. ("Inbreeding" is being used in this article in the broad scientific sense but most breeders of livestock use "inbreeding" only when referring to rather intense degrees of it.)

Inter se Relationship

There has been a gradual increase in the *inter se* relationship from 1860 to 1930. The *inter se* relationship is an estimate of the relationship that existed at the particular period between any two animals chosen at random from the sample. If the parents of the animals in the sample had been mated purely at random, so far as concerns their relationship to each other, the inbreeding (F) resulting merely because all members of the same breed are related to each other should be $F = \frac{R}{2\text{-}R}$

In Table I are shown the coefficients of inbreeding which would be expected with random mating in a population with the average *inter se* relationship which was found in the particular sample. In every case the observed coefficient of inbreeding was more than the expected. This means that on the average there was a closer relationship between the sires and dams than between contemporary animals taken at random. The difference between the expected and the actual inbreeding was most pronounced in 1890, 1910 and 1930 and least pronounced in 1900 and 1920. Apparently the breed is always tending, at least a little, to separate into slightly related families. However, the tendency toward family formation in the breed seems never to progress very far before the incipient families are used for top-crossing and are blended into the breed as a whole. The *inter se* relationship was higher in the special samples but it held about the same relation to the inbreeding as in the random samples. This

indicates that there was a slight tendency for the special samples to be groups distinct from the rest of the breed but that the special sample was itself tending, very slightly, to split into separate families, just as was the rest of the breed.

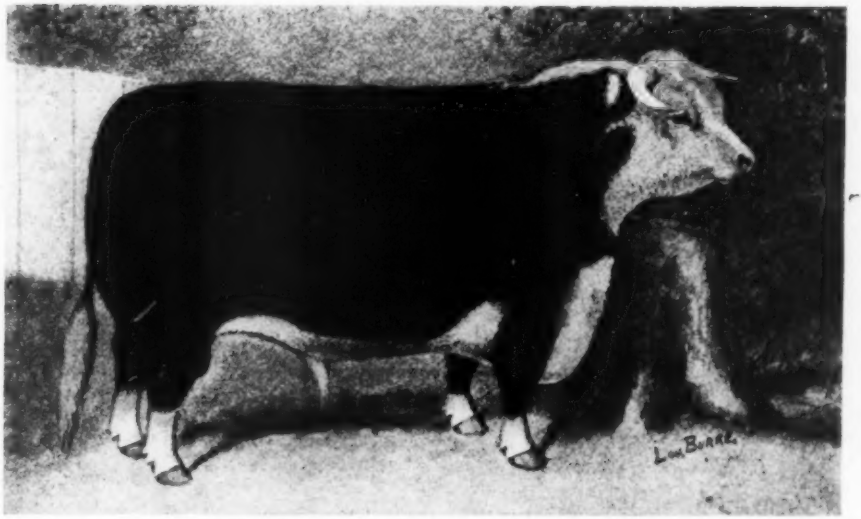
Prominent Individuals

This system of sampling pedigrees gives an objective measure of the importance of various ancestors in the breed at the particular period. If an animal appeared as an ancestor in many random lines, it had a good chance of scattering its genes throughout the breed. All of the bulls and cows which appeared 40 times or more in any one of the samples studied are shown in Table II. In the regular random samples taken at ten-year intervals an animal appearing 40 times in the 1,000 random lines would have a direct relationship of nearly 4% to the breed at the particular period. This figure is also subject to a sampling error which can be computed by the npq formula which, however, gives an asymmetrical distribution where the values for p and q are so unequal as they are in these cases. In case an animal appears 100 times, the standard error is about 9 appearances. The prominent ancestors of the 1870 sample were not counted since this sample was not put on cards for machine tabulation. The numbers shown in the last three columns (that is, in the special samples) should be a little more than doubled to make them comparable with the figures in the regular samples.

The information in Table II gives an idea of the influence the particular animal has had on the breed through its own descendants. Two animals may have the same direct relationship to the breed at a particular period and still the breed may be more like the one than the other because of the collateral relationship. The one animal may be the only connecting link between his ancestors and the breed while the other animal's ancestors may have had many other offspring through which their genes were conveyed to the breed. Table III gives the relationship, both direct and collateral, for the bulls and cows which appeared 40 or more times in one or more of the samples. Doubtless some animals with larger collateral relationships than some of those shown may have been overlooked by this method of selecting them primarily on the size of their direct relationship.

Beau Brummel 51817 was approximately a grandsire to the breed in 1930. He was calved in 1890 and used by Gudgell and Simpson for ten years. His sire was Don Carlos, the most extensively used son of Anxiety 4th and his dam was a daughter of North Pole. He won fifth in his class and second in the get of sire at the Chicago World's Fair in 1893. Gudgell and Simpson had been in quest of bulls to cross on their Anxiety 4th cows but had found none at this time and were starting the concentration of Anxiety 4th's blood in their herd. Beau Brummel's calves were beginning to attract the attention of the Hereford breeders at a time when herds were being established. For example, R. H. Hazlett used four sons of Beau Brummel on the foundation cows of his herd. The fact that Beau Brummel lived at this opportune time, and had a famous sire and famous grandsires, and was in one of the largest and most prominent Hereford herds in the country, and was owned by men who had decided to do linebreeding to his sire and grandsire, all contributed to his high relationship to the breed in 1930. In addition to this, the big demand for "straight-bred" Herefords following 1920 gave further stimulus to the use of his descendants. His sons and daughters gave good accounts of themselves and this played its part also. He lived long and sired 186 bulls and 221 heifers which were recorded in the American Hereford Record.

Don Carlos 33734, the sire of Beau Brummel, was nearly a grandsire to the breed in 1930. He was calved in 1886 and was used all his life in the Gudgell and Simpson herd. He was the most important son of Anxiety 4th. He lived at a time when the activity in the breed was at a low ebb, but he was used extensively in concentrating the blood of



"GRANDSIRE" OF THE HEREFORD BREED

Figure 6

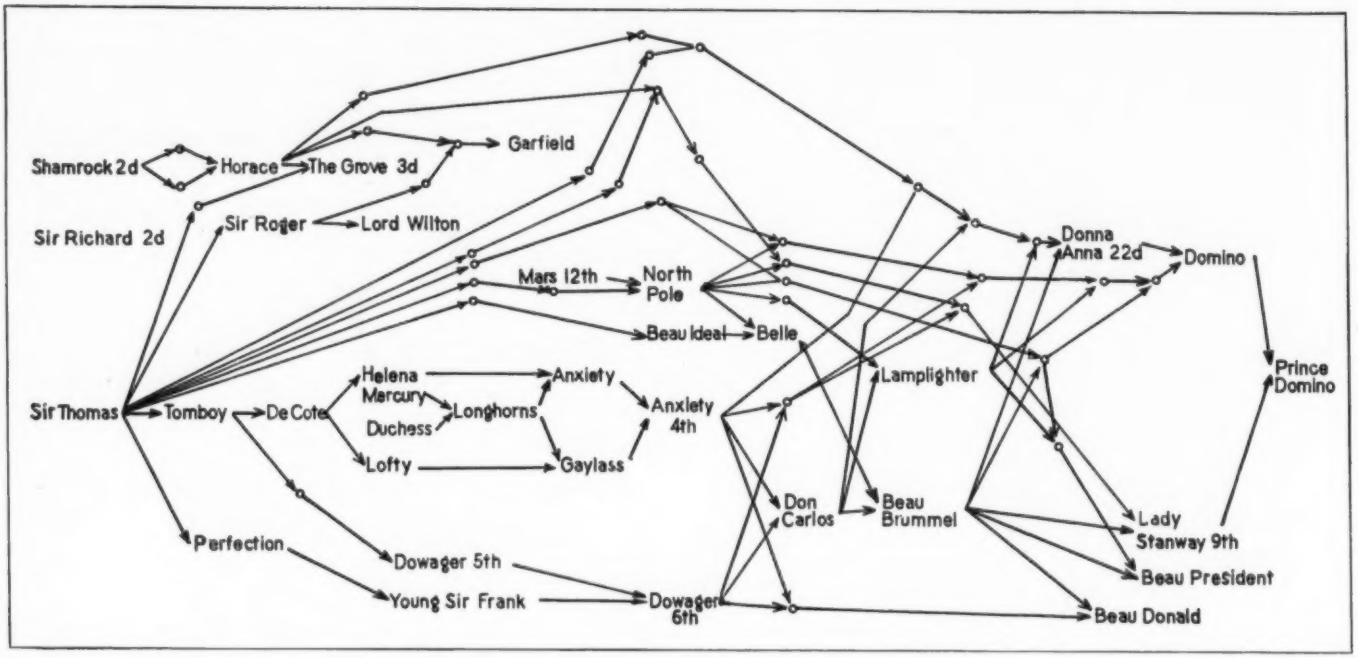
Beau Brummel 51817 was 24.6% related to the Hereford breed in 1930. This was the highest relationship found for any animal in this study. He was a grandson of Anxiety 4th and he and his offspring were used largely to concentrate the blood of Anxiety 4th in many herds.

Anxiety 4th. The fact that Don Carlos had seven full brothers and sisters used extensively in the breed helped to increase his relationship.

Anxiety 4th 9904 was 18.5% related to the breed in 1930. He was calved in 1880 and imported by Gudgell and Simpson in 1881, and used by them until his death in 1890. North Pole 8946 was imported at the same time by Gudgell and Simpson but he was used only 7 years in their regular herd and was then sent to Kansas to be used on grade cows. Anxiety 4th was used extensively on the daughters of North Pole with what seems now to have been excellent success. Apparently the owners were not too well satisfied with the results then. Gudgell and Simpson tried various outcrosses with the offspring of Anxiety 4th but were seemingly not satisfied with many of them. They then tried some close breeding in the family and the results pleased them. This evidently decided them upon a program of concentrating the blood of Anxiety 4th in their herd. If the concentration of his blood had started earlier his relationship to the breed would have been higher. North Pole did not have as high a relationship to the breed in 1930 as Anxiety 4th but it was remarkably high for a bull which seems never to have had a son used in a purebred herd.

Sir Thomas 20 maintained a high direct relationship to the breed from 1860 to the present time. If the base date had been a few years earlier, his relationship would have included more collateral relationship because his sire, Sir Benjamin 36, had some other important sons. The fact that Sir Thomas appears in the pedigrees of Anxiety 4th, Dowager 6th, North Pole and many other subsequently important animals gives him a high relationship to the breed. His blood is so well diffused through the breed at the present time that it would be hard to alter his relationship to the breed.

Lamplighter 51834, a three-quarter brother of Beau Brummel, is considered by some breeders as the most important son of Don Carlos, but this study shows his direct relationship to the breed to



RELATIONSHIP OF IMPORTANT SIRES AND DAMS

Figure 7

A random sample of the Hereford breed in 1930 traced back to a few important foundation animals in 1860—102 animals terminating 84 per cent of the lines traced back to that date. This is due in large part to the use of a few "key animals" in the foundation of the breed (See Table III). Most of the important animals are rather closely interrelated—as is shown in this chart.

be much smaller than that of Beau Brummel.

Beau Donald 58996, a son of Beau Brummel out of a full sister to the sire of Beau Brummel, was very important in Hereford history from about 1900 to 1920. This study shows that he had about the same direct relationship to the breed as Lamplighter in 1910 and 1920, but his direct relationship to the breed did not increase from 1920 to 1930 as did that of Lamplighter or Beau Brummel. Beau Donald was used largely for outcrossing. Therefore his descendants were not helped by the demand for "straight-breds."

On account of the limited number of offspring it is difficult for a cow to attain as high a relationship to the breed as is possible for a bull. Several cows with high direct relationships are found in Table III. Dowager 6th 6932 was approximately a great grandmother to the breed in 1930. Most of her influence has been exerted through two sons, Don Carlos and Don Quixote, and one daughter, Donna. She produced eight calves all of which were sired by Anxiety 4th. Belle 24629, a more recent cow, has about the same direct relationship to the breed as Dowager 6th in 1930, but all of her influence has come through her one son, Beau Brummel. Gayless 9905, has a high direct relationship to the breed in 1930. Practically all of her influence has come through her one son, Anxiety 4th.

In a study of this type it is possible to ascertain which sons and daughters of an animal have been most responsible for spreading its genes through the breed. One animal may have depended almost entirely on one offspring to transmit its genes, as in the case of Belle, while another may have had several almost equally important offspring, as had Dowager 6th. Table IV gives the ten sons and daughters of Beau Brummel which occurred most frequently in the regular random samples. These ten animals were responsible for 66% of Beau Brummell's appearances in 1930. Column 4 of the table gives the sires of the cows which produced these sons and daughters of Beau Brummel. The regularity of the breeding policy is seen from the fact that every sire of these ten cows to which Beau Brummel was so successfully mated was closely related to Beau Brummel himself either as a sire (Don Carlos), grandsire (North Pole and Anxiety 4th), three-quarter brother (Lamplighter), uncle (Don Quixote), or half uncle (Don Juan). Similar tables were compiled for other important animals and show such interesting facts as the following: Beau Brummel and Lamplighter were responsible for 74% of Don Carlos's appearances in the 1930 sample. Don Carlos, Don Quixote and Donna, full brothers and sister, were responsible for 48% of Anxiety 4th's appearances in 1930. Anxiety 4th was responsible for 61% of the appearances of Anxiety in 1930. It was interesting to note that seven sons and daughters accounted for all of Anxiety's appearances in recent years. Five of these seven animals were out of cows sired by Longhorns, the sire of Anxiety; that is, these five were double grandsons or granddaughters of Longhorns.

Average Length of Generation

The average interval between generations in this study was 5.4 years. This average is based upon 66,532 generation intervals and agrees well with the 5.3 years found by Lush and Lacy[8] in their study of 2,000 generation intervals in a sample from Volumes 75 and 76 of the Hereford herdbook. Table V gives the generation intervals found at the various periods. The generation intervals have tended to lengthen in recent years. The breed is perhaps approaching an equilibrium in numbers which would tend to make the average age of the animals higher than it would be if the population were still increasing rapidly in numbers. The "straight-bred" enthusiasm from 1920 to 1930 may have been responsible for part of this lengthening because many breeders tried to keep as long as possible the animals originally bred by Gudgell and Simpson.

Foundation Animals

The number of Herefords in the United States and England in 1860 was

Table I. Inbreeding and Inter Se Relationship Coefficients.

Year	Number of Pedigrees Sampled	Inbreeding Coefficients		Inter se relationship
		Actually found	Expected from inter se relationship	
1870	130	1.2	0.7	1.4
1880	500	2.9±0.5*	1.1	2.1±0.5
1890	500	3.4±0.6	1.3	2.6±0.7
1900	500	2.7±0.5	2.6	5.2±0.7
1910	500	4.9±0.7	2.7	5.3±1.0
1920	500	4.6±0.7	3.7	7.1±1.1
1930	500	5.1±0.8	4.6	8.8±1.2
R.O.M.	111	10.0±0.9	7.7	14.3±2.3
1920 S	211	7.8±1.3	5.3	10.0±2.0
1930 S	207	17.3±1.8	9.5	17.3±2.5

* The figures following the ± signs are standard errors in this article.

Table II. Animals found most frequently in the random ancestral lines.

Name	Registration Number	Calved	Number of times found in various samples '80	'90	'00	'10	'20	'30	ROM	S20	S30
Bulls											
Sir Thomas	20	1860	51	64	102	103	93	106	51	45	48
Shamrock 2nd.	768	1859	15	18	45	29	22	20	12	7	8
Sir Richard 2nd.	970a	1868	55	22	29	16	22	11	5	4	1
Anxiety	2238	1876	9	11	40	61	70	77	47	37	41
Longhorns	2239	1872	10	28	42	95	69	107	40	42	47
Mercury	2241	1870	10	13	28	42	31	50	24	17	22
De Cote	2243	1868	4	21	49	58	45	56	31	25	16
Tomboy	2249	1866	11	21	29	38	44	58	20	14	14
The Grove 3rd.	2490	1874	17	45	78	80	55	82	18	21	11
Horace	2492	1867	20	32	72	58	54	55	19	17	12
Young Sir Frank	2689	1871	5	2	5	14	30	64	29	26	22
Sir Roger	2850	1869	15	30	49	44	38	23	9	16	9
Lord Wilton	4057	1873	5	57	65	58	55	45	26	19	15
Mars 12th.	4482	1877	4	5	6	17	34	49	19	15	27
Garfield	7015	1881	0	11	28	43	28	25	13	19	12
North Pole	8946	1880	0	5	11	30	61	84	38	31	32
Anxiety 4th.	9904	1880	0	13	41	77	95	146	89	55	80
Don Carlos	33734	1896	0	1	17	42	94	148	82	61	75
Beau Brummel	51817	1890	0	0	5	44	108	153	92	78	104
Lamplighter	51834	1891	0	0	4	19	37	79	37	28	32
Beau Donald	58996	1893	0	0	5	18	30	76	33	33	20
Beau President	171349	1903	0	0	0	4	19	49	23	15	28
Domino	284259	1905	0	0	0	1	4	44	19	11	47
Prince Domino	409811	1914	0	0	0	0	0	26	18	9	69
Cows											
Helena	2240	1873	6	5	21	22	26	40	28	20	19
Duchess	2242	1863	5	16	19	55	44	69	17	25	26
Perfection	2875	1882	0	2	2	7	12	43	21	17	18
Dowager 4th.	4952	1877	0	1	9	26	64	127	61	41	64
Dowager 5th.	6953	1874	0	0	7	13	37	44	24	18	33
Gaylass	9905	1875	1	11	22	36	43	89	30	25	39
Lofty	9906	1872	0	5	12	21	15	42	13	10	18
Beau Ideal 8th.	9949	1878	0	2	5	17	30	57	24	17	30
Belle	24829	1885	0	1	4	25	61	98	40	21	54
*Lady Stanway 9th.	171354	1903	0	0	0	0	3	30	18	7	39
*Donna Anna 22nd.	189218	1903	0	0	0	0	3	25	12	7	31

*These two cows have been included in the table because they occur more frequently than any other cows which were calved after 1900.

Table III. Total relationship of prominent animals to the various samples.

Name	Registration Number	Calved	'80	'90	'00	'10	'20	'30	ROM	S20	S30
Bulls											
Sir Thomas	20	1860	5.0	6.3	10.0	10.1	9.1	10.3	11.0	10.3	10.7
Shamrock 2nd	768	1859	1.5	1.8	3.9	2.9	3.1	1.9	2.6	1.6	1.1
Sir Richard 2nd	970a	1868	5.9	2.1	3.1	1.6	2.2	1.1	1.4	0.9	0.2
Anxiety	2238	1876	2.1	3.0	7.4	11.0	10.6	12.9	14.5	13.4	13.4
Longhorns	2239	1872	1.5	3.3	4.9	9.6	7.4	10.8	8.8	10.3	10.8
Mercury	2241	1870	2.3	2.5	3.9	4.8	3.8	5.6	5.4	5.0	5.4
De Cote	2243	1868	1.1	3.0	7.4	8.1	7.2	6.4	9.6	8.4	9.0
Tomboy	2249	1866	3.6	5.0	7.3	7.9	7.5	7.6	8.6	9.1	7.6
The Grove 3rd.	2490	1874	5.6	6.8	12.0	10.1	8.9	7.0	7.2	8.5	5.9
Horace	2492	1867	2.3	3.6	7.7	6.1	6.0	3.5	4.2	4.2	2.9
Young Sir Frank	2689	1871	2.2	2.3	3.6	4.6	5.9	9.1	11.3	9.1	7.9
Sir Roger	2850	1869	4.0	6.4	8.3	9.3	8.1	8.1	7.8	8.7	7.4
Lord Wilton	4057	1873	2.8	8.1	9.4	9.2	8.7	7.5	9.1	8.1	6.2
Mars 12th	4482	1877	1.3	1.2	1.2	2.1	3.8	5.1	4.4	3.7	6.4
Garfield	7015	1881	1.3	3.0	5.4	6.9	5.0	4.7	4.6	5.6	4.2
North Pole	8946	1880	1.5	1.6	2.7	4.6	7.4	9.6	9.7	8.3	13.3
Anxiety 4th.	9904	1880	1.2	3.7	7.8	12.8	13.0	18.5	18.8	16.9	20.8
Don Carlos	33734	1896	1.5	3.2	6.6	11.1	15.3	22.6	26.0	21.5	26.0
Beau Brummel	51817	1890	1.2	2.2	5.0	10.4	17.0	24.6	28.9	24.4	32.7
Lamplighter	51834	1891	1.1	1.9	4.5	7.7	12.1	19.0	19.3	17.2	15.3
Beau Donald	58996	1893	1.3	3.5	4.4	10.4	13.7	16.5	20.6	19.5	21.2
Beau President	171349	1903	1.0	2.0	4.2	8.0	13.9	18.7	20.6	20.6	24.2
Domino	284259	1905	1.1	2.4	4.4	8.0	12.2	17.4	17.4	19.8	23.9
Prince Domino	409811	1914	1.1	3.1	4.4	7.7	9.2	14.7	20.9	17.4	29.3
Cows											
Helena	2240	1873	1.7	3.4	5.7	6.4	8.9	7.5	10.0	8.2	6.5
Duchess	2242	1863	0.3	1.6	1.8	5.2	4.4	5.7	3.6	5.7	5.7
Perfection	2875	1882	2.2	3.3	5.2	5.5	5.4	6.2	6.9	6.3	6.7
Dowager 4th	4952	1877	1.5	2.1	3.6	5.2	8.7	12.4	15.2	12.9	14.8
Dowager 5th	6953	1874	0.2	2.0	2.9	3.6	5.7	8.1	7.6	6.7	9.2
Gaylass	9905	1875	1.4	3.6	5.2	6.1	10.4	13.2	11.2	11.0	13.3
Beau Ideal 8th	9949	1878	1.9	3.2	3.4	5.1	5.8	8.4	7.9	7.4	8.9
Belle	24829	1885	1.7	2.5	2.2	4.0	9.4	13.0	12.9	11.0	16.9
Lady Stanway 9th	171354	1903	1.2	1.5	4.2	7.9	11.1	18.5	20.2	17.4	25.0
Donna Anna 22nd	189218	1903	1.3	3.2	4.3	8.9	12.3	17.7	17.9	19.9	24.6

*The standard errors for the relationships in the regular samples can be seen from the following scale:

Coef.	S. E.	Coef	S. E.
2	0.4	10	1.0
4	0.6	14	1.1
6	0.8	18	1.2
8	0.9	24	1.4

The standard errors in the last three columns will be about 80% larger.

Table IV. Number of random ancestral lines which traced to Beau Brummel through his most important sons and daughters.

Name of Offspring	Number	Calved	Sire of Dam	Number	'80	'90	'00	'10	'20	'30	'40	Total
Beau President	171349	'03	Lamplighter	51834	19	8	2					29
P. Lady 16th	58707	'93	North Pole	8946	3	2	1					22
Beau Donald	58996	'93	Anxiety 4th	9904	15	18	10		8			45
Lady Stanway 9th	171354	'03	Don Quixote	37705	14	8				1		17
Donna Anna 22nd	189218	'03	Lamplighter	51834	13	1				2		14
Militant	71756	'98	Don Carlos	33734	5	6	2		2			16
Beau Brummel 10th	167719	'02	Don Carlos	33734	5	2						7
Br. Countess	71651	'98	Don Juan	11069	4	5						9
Redmont	134781	'00	Don Carlos	33734	4	5				1		9
Beau Donald	109748	'00	Anxiety 4th	9904	2	4				2		8
Percent of Beau Brummel's total appearances					68	51	43		80			56

Table V. The average length of generation intervals in Herefords

Sample	Generations to foundation animal	Years per generation	Average years to foundation animals
1930	12.9	5.6	72.3
1920	11.5	5.4	61.8
1910	9.8	5.3	52.0
1900	8.1	5.2	42.2
1890	6.4	5.1	32.6
1880	4.4	5.2	22.8
1870	3.0	4.9	14.9
R.O.M.	10.5	5.4	56.9
1920 S.	10.8	5.6	61.1
1930 S	12.4	5.8	72.0
Average		5.4	

Table VI. Number of different foundation animals each found at the end of 1,2,3 or more of the 1000 random lines traced back from the pedigrees of the animals calved in 1930.

Number of times animal appeared	Number of animals	Bulls	Cows
1	98	43	55
2	35	17	18
3	19	8	11
4	11	6	5
5	9	1	8
6-10	23	13	10
11-20	15	11	4
21-50	4	4	0
106	1	1	0

Table VII. Breeders who bred a large percentage of the foundation animals.

Breeders	1930 Sample		All samples combined	
	Foundation animals bred	Per cent of lines stopped	Foundation animals bred	Per cent of lines stopped
Lord Berwick	11	3.8	29	5.7
Lord Bateman	8	2.5	15	4.3
Edwards	10	3.8	18	3.7
H. Gibbons	2	0.9	5	1.3
J. Green	5	2.2	16	2.0
J. Hewer	13	2.7	47	4.2
W. Parry	5	0.8	12	1.1
G. Pitt	6	0.8	19	1.0
T. Powell	2	0.4	6	1.2
E. Price	6	4.1	27	5.3
J. Monkhouse	4	1.3	11	1.4
J. Rea	11	10.1	42	8.8
T. Rea	5	2.2	9	4.3
T. Roberts	8	14.4	23	11.1
B. Rogers	15	13.7	34	12.4
Stedman	3	1.7	7	1.6
J. Stephens	4	2.5	4	1.4
F. Turner	11	4.7	22	4.4
W. Tudge	8	3.1	16	3.4
W. Taylor	1	3.3	10	1.9

small as compared with the number in the United States in 1930. It would not be expected that all of those animals living in or near 1860 would be equally important in furnishing the ancestors for the Herefords of 1930 in the United States. In the seven regular samples in this study 113 animals were responsible for the ends of 75% of the random ancestral lines. Only 102 animals were responsible for 84% of the 1,000 lines in 1930. Table VI gives a summary of the foundation animals in the 1930 sample. If all of the animals appearing three times or less were eliminated there would have been 66 animals closing about 77% of the random ancestral lines. A few important foundation animals have furnished a large part of the genes from which the Hereford breed of today has been formed.

An attempt was made by means of four line pedigrees to study the breeding of the 113 foundation animals mentioned above, but it was impossible to trace many of their pedigrees back of 1860 and for this reason no reliable estimate of their inbreeding or *inter se* relationship relative to an earlier date was made.

From 20 herds came the foundation animals in about 83% of the random lines in 1930. These same 20 breeders were responsible for 80% of the foundation animals in the combined samples. T. Roberts, B. Rogers, and J. Rea bred the foundation animals in about 38% of the 1930 lines and 32% of the lines in the combined samples. Table VII gives a brief summary of the findings concerning the foundation breeders.

Discussion

Selection is the simplest and most widely used tool of the animal breeder but there are certain desirable ends it will attain but poorly or not at all. In many genetic situations fast progress is made with selection when it is first begun, but as the goal is approached the progress becomes slower. Dominance, environment, and that type of gene interaction known in genetics as epistasis, or generally by the breeder as "nicking," decrease the progress made by selection. Selection for a dominant reaches its maximum effectiveness when the frequency of the desirable gene is about 1/3. Selection for a recessive is correspondingly most effective when the desired gene occupies about 2/3 of the loci possible to it. When a gene reaches high frequencies the effectiveness of selection falls so low that it is held in equilibrium even by feeble mutation rates, and selection is almost powerless to bring about complete fixation, in spite of its ability to alter moderate frequencies. Only part of the quality selected for in the parents is actually gained in the offspring when selecting for a character which is much modified by environment. Most characters sought in animal breeding are affected by several factors and this slows the progress made by selection. Some of these weaknesses of selection may be remedied by combining some inbreeding with the selection.

Inbreeding fixes characters by causing one of the members of a pair of alleles to be lost. When the frequency of the desirable gene is equal to that of the undesirable gene, inbreeding in the absence of selection is just as likely to fix the undesirable as the desirable gene. Inbreeding in the absence of selection and in the presence of dominance will cause the mean of the zygotes to shift toward the recessive side. Since most recessive genes have effects which are considered undesirable, this usually leads to some average decrease in desirability under an inbreeding system, especially if the inbreeding has been too extreme to be kept under control by selection.

The Hereford breed has as a whole on account of the inbreeding practiced, become homozygous for about 8% of the genes which were still heterozygous in the foundation stock in 1860. This rate of fixation of 0.68% per generation is slow as compared with the 2.5% per generation found in the breed from 1920 to 1930. What would have happened had this faster rate of fixation been under way since 1860? We are still much in the dark about how rapid a rate of inbreeding can be guided safely by selection. Yet the thought persists that it

may have been a needless waste of time to take 70 years to do work which might possibly (?) have been done as well in 20 or 30 years.

Summary and Conclusions

1. The inbreeding coefficient for the Hereford breed rose to 8.1% in the 12.9 generations from 1860 to 1930.

2. The *inter se* relationship in the breed was 8.8% in 1930. This would have resulted in an inbreeding coefficient of about 4.6% if random mating had been practiced in the group. The fact that the actual inbreeding coefficient was higher than this, indicates a tendency toward the formation of separate families. This tendency rarely progresses far. It is held in check by the crosses between families which keep the *inter se* relationship coefficient rising, but at some distance behind the inbreeding coefficient.

3. Nearly all of the animals which had unusually high relationships to the breed at the various periods were either the ancestors, descendants or mates of Anxiety 4th. The breed was 18.5% related to Anxiety 4th in 1930. Beau Brummel, a grandson of Anxiety 4th, had the highest relationship to the breed of any of the animals in the study. He was 24.6% related to the breed in 1930. Several other bulls and a few cows which were the dams of important bulls had high relationships to the breed.

4. The special groups of prize winners and the Register of Merit animals had higher coefficients of inbreeding and of *inter se* relationship than the contemporary random samples. These special groups were also more highly related to Anxiety 4th and his descendants. The ratio between the inbreeding and the *inter se* relationship was similar to that in the random samples, indicating about the same slight tendency for family formation in the special groups.

5. The average interval between generations was 5.4 years.

6. One hundred and two foundation animals were responsible for the ends of 84% of the 1,000 ancestral lines in 1930.

7. Twenty English breeders were responsible for the breeding of the foundation animals in which ended over 80% of the random ancestral lines traced in this study. Three of them bred 38% of the foundation animals (1930 sample).

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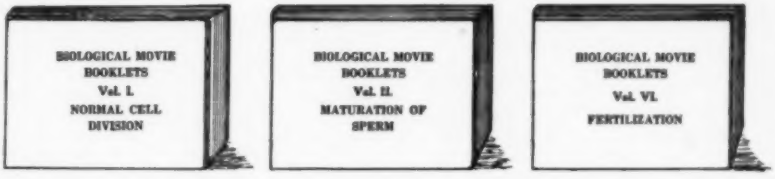

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1 Slide of each of above (9 slides—6 drawings)	25.00

* Three or more slides, 1 of each kind @ $3.50 each. Three or more of same kind @ $3.00 each.

SALIVARY GLAND CHROMOSOME MAPS

Painter's cytogenetic map of the salivary chromosomes, 9½ by 18 inches, line-cut showing major chromosome details and the genes approximately located to end of 1934, mailed unfolded	$ .50
Bridges' reference map of the banding of the salivary chromosomes, 9½ by 25 inches, halftone on heavy coated paper, unfolded	1.00
Folded copies of Bridges' map, on lighter paper	.35
Hughes' map of Salivary Chromosomes of *Drosophila Virilis* (9½ by 18)	.75
1 copy each of Painter's, Hughes', and Bridges' maps	2.00

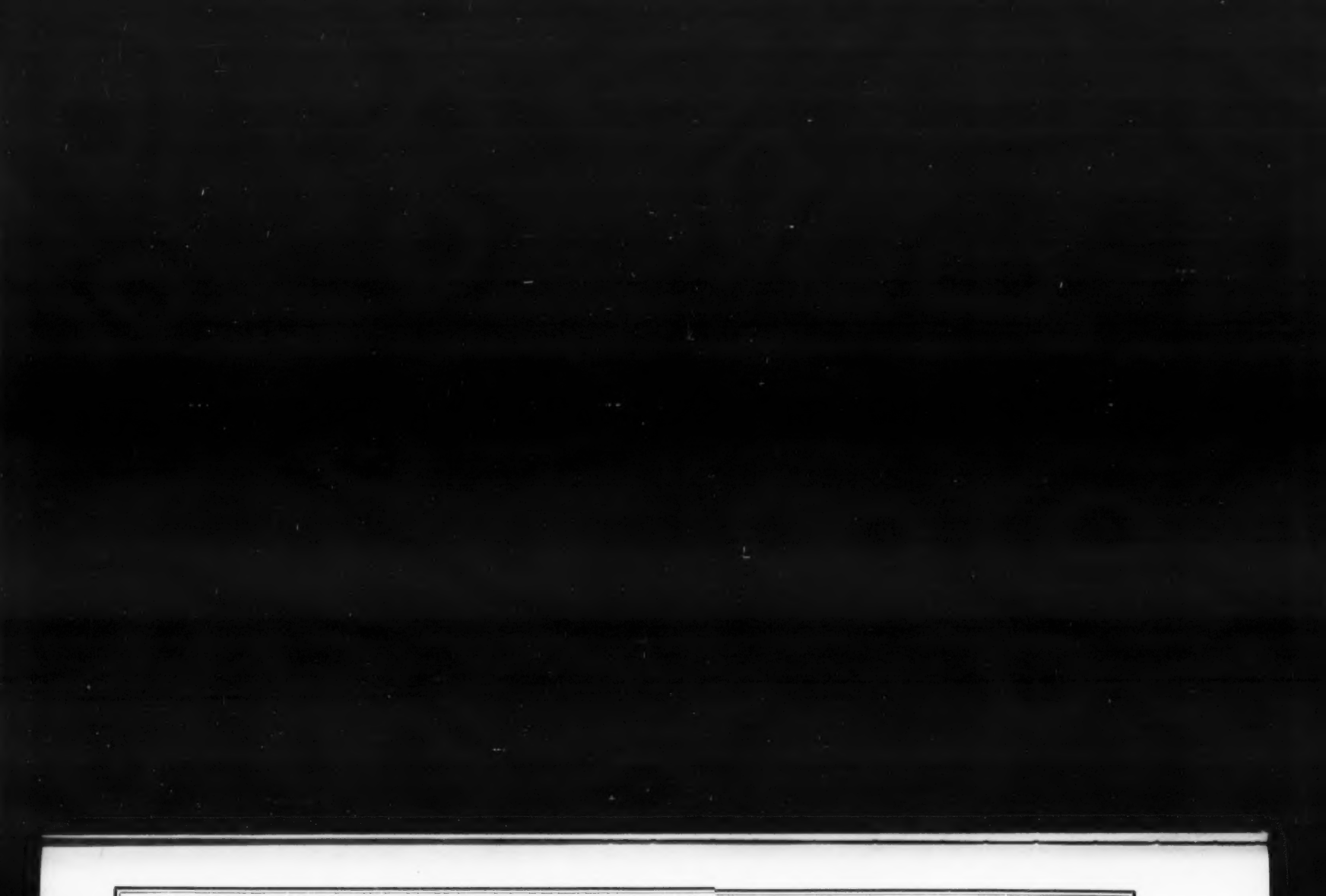
LANTERN SLIDES OF SALIVARY CHROMOSOME MATERIAL

†21-323. Salivary chromosomes in the Nucleus	$ .75
25-464. "Portrait" of a Salivary Gland Chromosome	.75
25-466. Giant Chromosomes Compared with "Normal", showing relative sizes	.75
25-469. Synapsis of Normal and Inverted Chromosomes	.75
25-470. Synapsis of Normal and Deleted Chromosomes	.75
25-472. Painter's Cyto-Genetic Map of Salivary Chromosomes (Insert)	.75
26-62. Salivary Chromosomes and Gonial Chromosomes Compared	.75
26-62. Bridges' Reference Map of the Salivary Chromosomes of Drosophila	.75
26-176. Salivary Gland Chromosomes of Sciara Compared with Normal	.75
26-179. Salivary Gland Chromosomes in the Cell (Sciara)	.75
26-182. Structure of Salivary Gland Chromosomes	.75
27-305. Map of Salivary Gland Chromosomes of *D. Virilis*	.75
Set of 12 Lantern Slides	8.00

† Volume and page number of illustration in the JOURNAL OF HEREDITY.

ILLUSTRATED LITERATURE

"Symposium Reprint" on Salivary Gland Chromosomes, containing articles from JOURNAL OF HEREDITY by Painter, Bridges and Hughes and three Salivary Gland Chromosome maps. Twenty-four pages	$2.50

AMERICAN GENETIC ASSOCIATION

Victor Building **Washington, D. C.**